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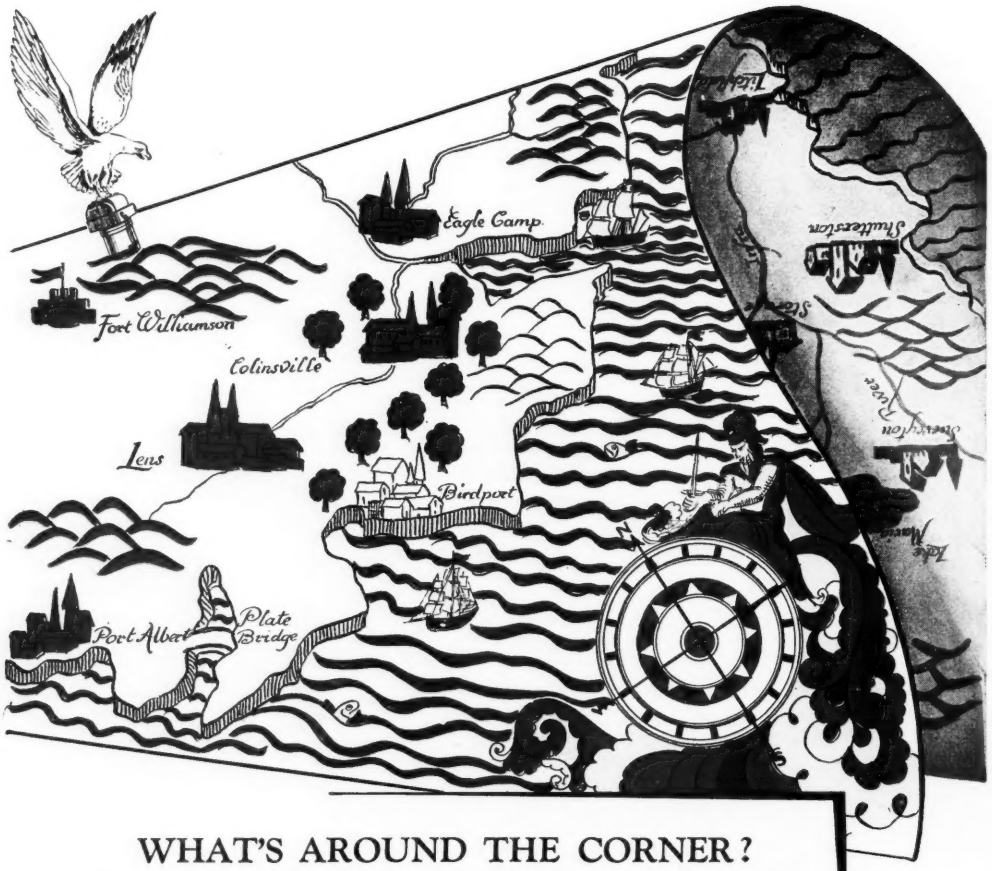

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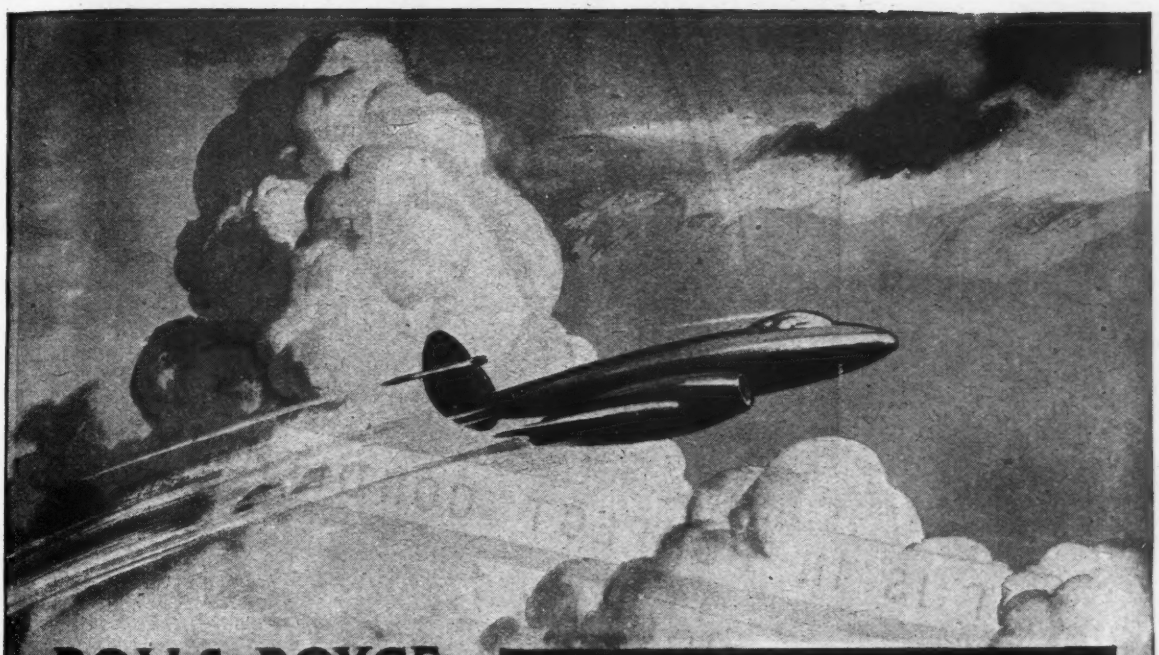

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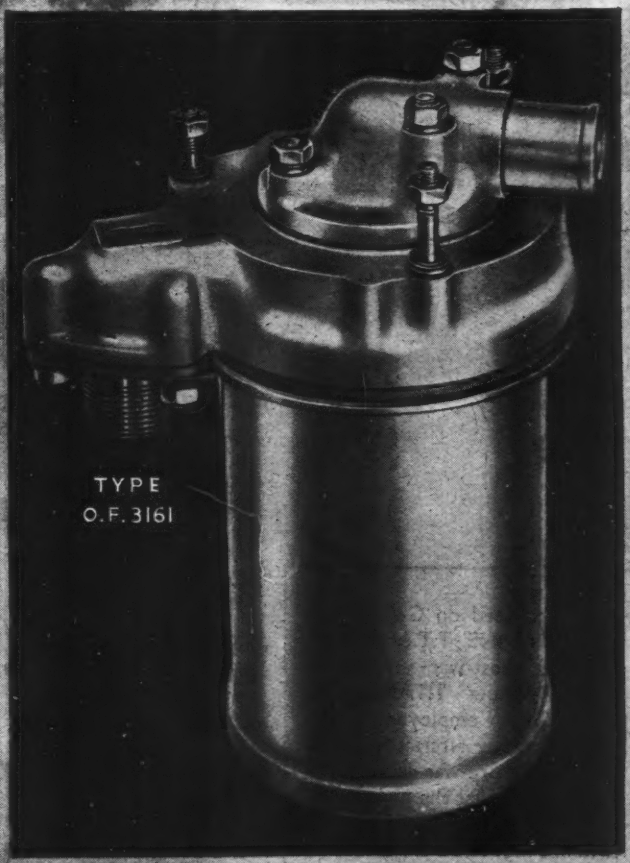

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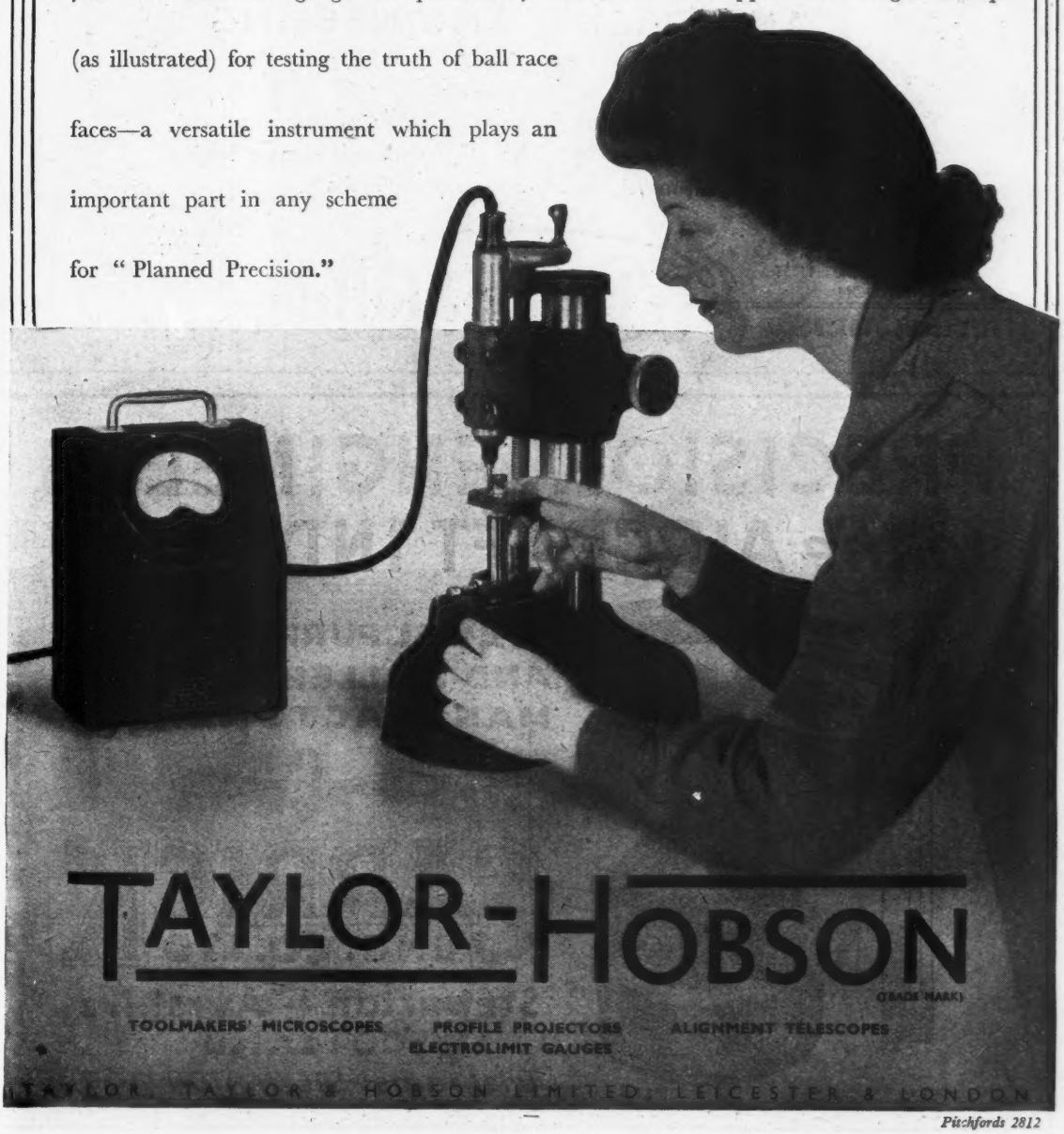

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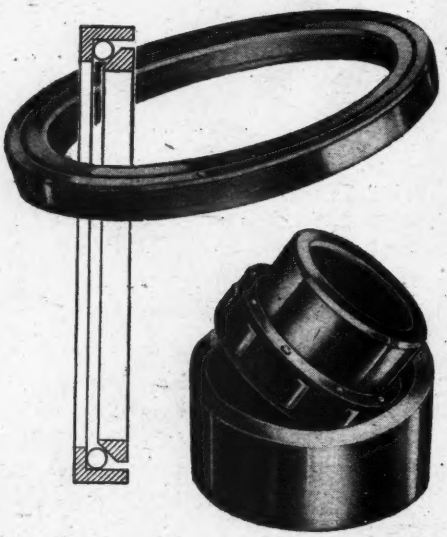

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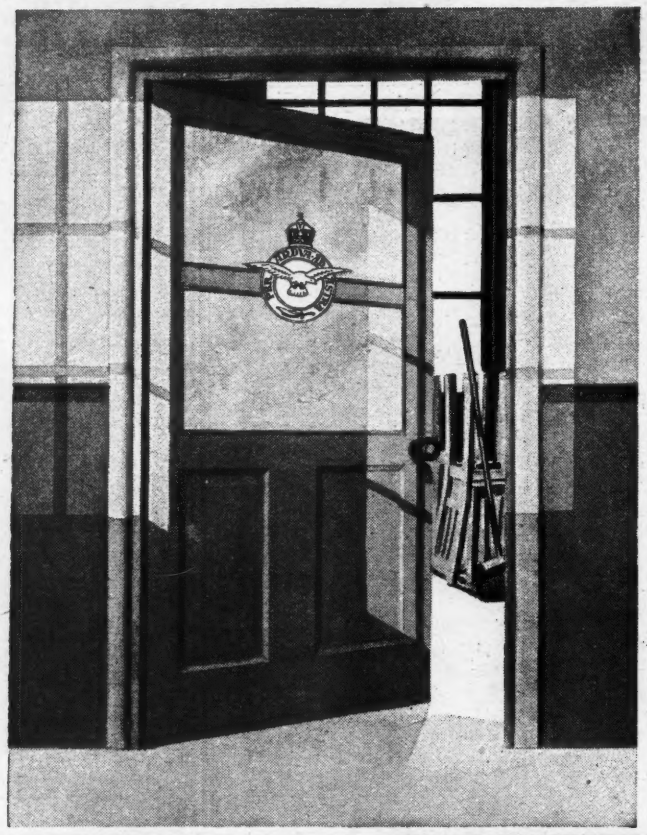

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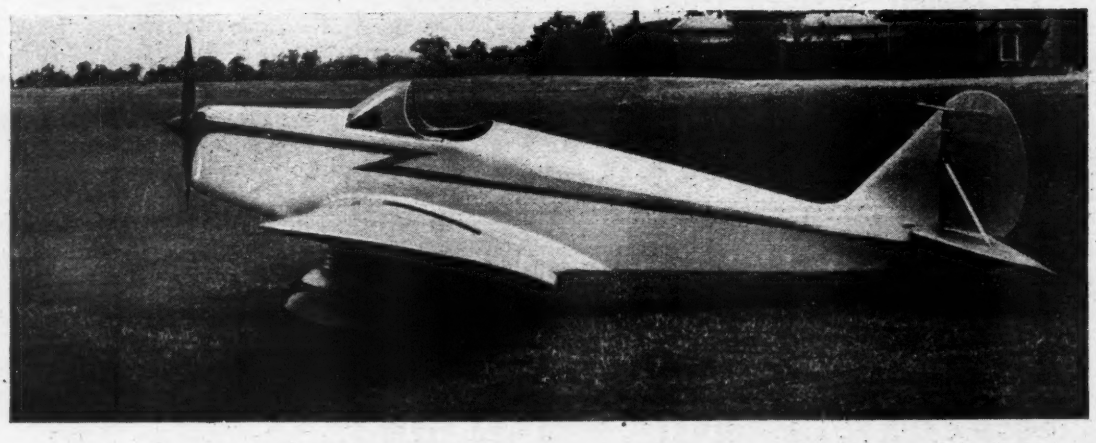

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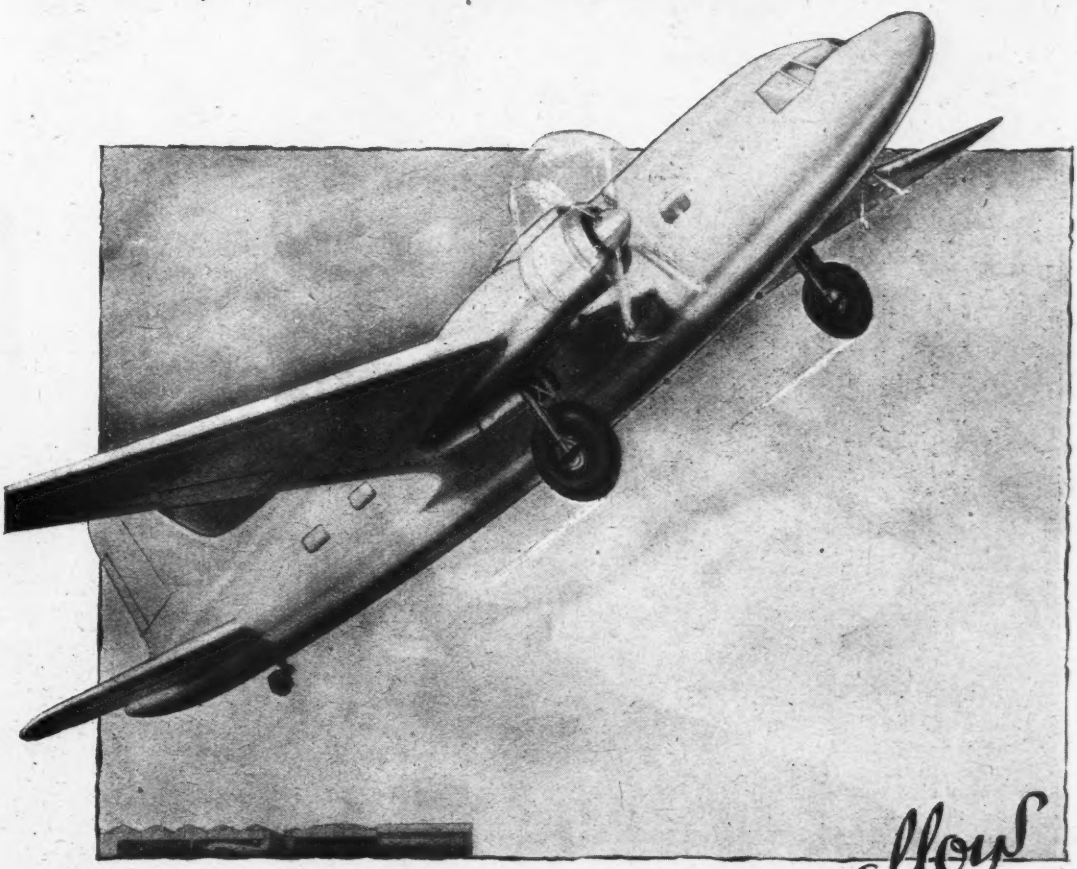

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The Outlook

The Next Stage

ALTHOUGH we appreciate the need for surrounding with some degree of security silence our more advanced civil aircraft projects, we think that the time has certainly come to give at least a few broad facts about the types which are eventually to succeed those of the "interim" period.

The question being asked nowadays is: Exactly what have we got actually on order in the way of civil aircraft to follow the various Short boats, the Tudors and the Vikings? The only statement so far made has been a vague reference to jet or airscrew/turbine-powered aircraft which will duly surprise the world. We feel that, if we really have got anything good up our sleeves, the time has come to be just a little explicit—both to encourage the public in this country and to increase our prestige abroad.

It might be enough merely to give an outline of the specifications and an approximate indication of the expected performances. Presumably some specifications have been drawn-up—and there must be some interesting private ventures, if not Government-sponsored projects, though it does not appear that any prototype orders have yet been placed.

What exactly are the types which are expected to fill the hiatus which at present follows the stage of "intermediate" civil production—and who is going to make them?

Incidentally, those who are so desperately unhappy about the B.O.A.C.-sponsored decision to purchase Constellations for temporary use on the Atlantic run, may find a grain of comfort in one fact. During the period in which only the Constellations would, in any case, have been available for the service, we shall be receiving fares in sterling and not losing them in dollars. Using round figures of five services a week each way, each carrying twenty passengers at £100 for the single journey, and suggesting that the Constellations will be in use for six months before British aircraft would otherwise have been in service, the net receipts will be £520,000. With the operational experience obtained and the good effect of running a British service, even with foreign aircraft, the financial advantages might be considered to tip the scales in favour of the purchase.

Bermuda Conference Settlement

THE news that the Bermuda talks between delegations from the United Kingdom and the United States have concluded on a satisfactory note is indeed welcomed. During a whole month of discussion and negotiation there have been conflicting rumours of agreement and of difficulty. When, however, at the beginning of this month there was an apparent hitch in the proceedings, and the delegates had to refer back to their respective Governments, it became clear that, for good or ill, something definite was about to emerge.

The Chicago Conference of 1944 showed that there were very definite differences of opinion between the two countries on many facets of post-war civil aviation. America wished to avoid any restriction on her exploitation of air transport. This was natural in a country which had, at that time, almost a monopoly of air transport potential. We, on the other hand, wanted the development of international air routes to be orderly, and fares and services to be regulated by international agreement. Cut-throat competition had to be avoided at all costs, otherwise our future position in the sphere of civil aviation was seriously jeopardised. Details of the terms of the Bermuda agreements have not yet been studied, but it is clear that, in reaching a basis, both America and ourselves have given way on some points, and that neither country has secured recognition of all the points of its policy. We sought international control of rates and we have gained this point. America wished to avoid any restriction on service frequencies, and this has been conceded. Most important, now-

ever, is the agreement to regular collaboration between the two countries so that new problems may be dealt with as they arise. This is something entirely new. In order to ensure that this collaboration is really effective, a representative of the U.S. Civil Aeronautics Board will work continuously in London with the Ministry of Civil Aviation. Similarly, a representative from our Ministry will remain with the C.A.B. There is no doubt that this day-to-day collaboration will prevent petty differences of opinion from gaining the magnitude of international crises. If squabbles on air transport matters are avoided by America and ourselves, the future outlook is a great deal brighter.

The most talked-about feature of the agreements is the controversial "Fifth Freedom,"—the establishing of the right for either country's airlines to embark or disembark traffic at intermediate points on international air routes. The agreements, however, contain safeguards so that this practice may not be employed in such a way that the carrying capacity of international airlines affects adversely the claims of regional and local services. In fact, ultimately, the number of seats available on aircraft on international through-airlines will be controlled by the number of through-passengers travelling from terminus to terminus. Thus, it is hoped that this "fill-up" traffic will really be fill-up and nothing more.

It is now up to the aeronautical authorities of the two countries to ensure that not only the letter, but the spirit of these agreements is observed, for their success should do much for the ultimate good of civil aviation.

A word of praise for the British delegation is merited. It had a difficult task, it was outnumbered approximately in the ratio of two to one, yet it achieved as much as could reasonably be expected. Its small size was probably not altogether a bad thing and may have facilitated complete unanimity.

A Well-deserved Compliment

THE appointment of Marshal of the Royal Air Force Sir Sholto Douglas to succeed Sir Bernard Montgomery is a compliment to the Royal Air Force and to Sir Sholto himself. His appointment is not analogous to that of Lord Tedder when he was made Deputy Supreme Commander under General Eisenhower, but rather to that of Air Chief Marshal Sir Robert Brooke-Popham who was appointed Commander-in-Chief in the Far East some years ago.

The British zone in Germany is occupied by the British Army of the Rhine and the Air Force of Occupation. As Military Governor of the British zone and as British member of the Allied Control Council for Germany we have no doubt that Sir Sholto will add to the reputation which he has already earned for the Service and himself.

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N.G.T.E.

THE announcement that Power Jets is to become the National Gas Turbine Establishment and controlled as are the other Government establishments need cause no surprise. The position of a "private" company, even if Government-owned, having control of such a research establishment was somewhat anomalous and was always regarded as merely a stop-gap measure. As we pointed out when Power Jets (Research and Developments), Ltd., was formed, the arrangement contained elements that could become undesirable. That, fortunately, has not happened, thanks to the good sense of those responsible for guiding the firm, but it is on every score more logical to have gas turbine research for the nation conducted by a Government establishment as researches and experiments in other directions are conducted at the R.A.E., for example.

FOR THE TROPICS: An Avro York taking off from Hurn Airport in the New Forest for the run to West Africa.

"Indicator" Discusses Topics of the Day

Length and Breadth

The Heathrow Controversy : The Importance of Directional Variety : A Brabazon Anomaly

IT is so very easy to be sarcastically destructive about anything and to write "open letters" to people who are not at all in a position to answer them that I am wondering whether it is quite fair to add to the thousands of words which have already been written about our old friend Heathrow. Were it possible to be in several hundred places and to read several hundred minds at the same time, it would be much more easy to take honest advantage of one's privileged position as a producer of letterpress and to lay down the law about this and that with a clear conscience.

As it is, the consciences of writers can remain tolerably quiescent in the knowledge that elephants, however white, are extraordinarily strong animals and are prone to proceed in a straight line regardless of the arrows of their enemies.

They may, however, be stopped quite dead sometimes by a single large-calibre projectile. And my projectile may be considered as large because, following Einsteinic reasoning, it is aimed at an even larger target than the Heathrow elephant. It is aimed, in fact, at most of the runwayed airfields that have been laid down in this country.

While everybody has been getting so excited about the need for new and enormous terminal buildings, or for longer and better taxying tracks and runways, or for more and more concrete to take the weight of bigger and better aircraft, only one or two critics—those with personal experience of the practical conduction of large aircraft—appear to have seen the only real red light.

Briefly, the six landing directions provided by the now standard three-runway arrangement are not enough for present-day aircraft, and will certainly not be enough for any future giants.

You may have the longest runways in the world and you may duplicate or even multiply them until the entire airfield looks like an inebriate's heaven, but sheer length or multiplication will not alter the fact that the chosen lines may, at any moment, be as much as 30 degrees out of a 60-mile-an-hour wind.

Four Runways a Minimum

Ever since runways were first invented, and certainly during the war when more or less standardised airfields were laid down by various contractors in hundreds, the plain triangle, with or without an encircling perimeter track, has been, so to speak, an accepted fact, and I cannot help feeling that the sooner we are able to think in terms of an absolute minimum of four runways the better it will be. Although it is quite true that an experienced aircraft captain has little difficulty in competing with cross-wind arrivals, and that, due to its considerable momentum, a heavy aircraft can generally be more easily landed across wind, there is a very definite limit to the success of the technique employed, and the kind of ground-looping risks which were happily taken with bombers and transports during a war cannot decently be repeated in peacetime.

For the moment, the medium-large aircraft in ordinary use can, in fact, be handled fairly safely in cross-wind conditions, but we are still asking a very great deal of the pilot; and as sizes and weights increase, the stresses involved in correcting incipient swings during take-offs or landings will be more than the tyres and undercarriages can be expected to take. Furthermore, all aircraft are not equally easy to handle, either in a drift-neutralising attitude or in a last-minute straighen-out from a crabbing approach, and even the natural qualities of the tricycle undercarriage will not save the airframe from excessive loadings if an aircraft *is* put down with drift.

On many occasions during the war, even with three available runways and a comparatively clear conscience as far as crash risks were concerned, pilots have found it necessary to abandon a take-off or to make for another airfield with a more suitable runway because the amount of drift just could not be tolerated. At one moment at least, when taking off a four-engined type with a very great deal of fin area, I found myself half-way down a runway while still holding full rudder and quite unable to bring up either of the starboard throttles sufficiently far to become airborne. The take-off was inevitably abandoned at a considerable cost in brake linings and nerves. Yet the runway was the best of three, and the wind was not excessively strong—it just happened to be as far off the runway as it was possible for it to be.

Tricycle a Help

Of course, the increasing standardisation of the directionally stable tricycle will help very considerably, particularly where take-offs are concerned; but, at least in this country, the majority of our civil aircraft are likely to be conventionally undercarriaged for at least the next two years. And there are many occasions during a normal year when neither take-offs nor landings are safely possible at any one particular airfield, and many more occasions when they are fraught with more than a reasonable amount of minor risk.

Nearly everybody, in saying their pieces about Heathrow, have been primarily concerned with its ability to deal with very large amounts of traffic and with future aircraft requiring immensely long landing and take-off runs. Yet it seems to me that an *additional* three thousand-yard runway will be far more useful than either a three-thousand yard extension of an existing runway or a duplicate in the same direction. In normal conditions of weather, aircraft can be landed and taken off quite as expeditiously as is at present necessary, even with the conventional Service airfield layout, provided that the control personnel are up to the job, while in bad weather it would never, in any case, be possible to permit, say, an aircraft to approach one runway on S.B.A. while any other aircraft was preparing to take off from a parallel runway. Only the Idlewild tangential runway scheme would make this possible—and such a scheme, in useful form, would be more expensive and expansive than anything we can at present contemplate.

Those who have watched American squadrons coming in after an operation will know just how tightly packed the arriving aircraft *can* be, with well-disciplined and experienced captains. The difficulty during such performances was always that of breaking up the circus momentarily while an aircraft was allowed to take-off. Here, admittedly, the parallel runway arrangement would, in good weather, be a convenience, but it should certainly not yet be a necessity in the present density of civil air traffic.

If I were asked to make a decision on priorities in airfield planning I would go first for the provision of a maximum number of landing directions, and then for really adequate terminal buildings, for runway extensions and, finally, for runway duplication and rational taxy track development. The tangential scheme is, eventually, the obvious one, but who is going to pay for it and

LENGTH AND BREADTH

where are we going to find the space for double lengths of two-mile runways?

* * *

One or two people appear to have been in vague disagreement with the suggestion, in the "Speed and Thrust" article of January 17th, that the thrust of a jet unit is not, in fact, constant at all speeds and heights. In the article I said, in effect, that the thrust drops away at altitude because the unit "cannot be fed with the same weight of air," and I can so far see no reason for recanting. Of course, in a quite theoretical universe, the thrust *might* remain constant, but for this it would be necessary that aircraft should have no drag, or that blowers and turbines should be capable of infinitely high rotational speeds.

To take one instance: At a height of 25,000 ft. the density of the air is approximately half of that at ground level. With the compressor rotating at the same speed it would be necessary, therefore, for the aircraft to travel twice as fast as at ground level to enable the intake to "grasp" the same weight of air—which would; at 25,000 ft., be filling twice the equivalent volume of space. If one thinks of the air in front of the jet intake as being simply a cylinder, it is obvious that, if the air is half as dense as at ground level, this intake must move twice as far in the same time if it is to gather up a ground-level weight of air in that time. Naturally enough, since, in spite of a proportionately lower overall drag in an air of less density, the good old law of the drag increasing as the square of the velocity still largely holds, this increase of speed is impossible, and the unit cannot therefore, in these conditions, be "fed with the same weight of air."

Consequently, the only way in which thrust could be maintained would be by increasing the rotational speed of the compressor to make up for the loss, and so continue to provide an equal weight of air in the combustion tubes, permitting the same amount of fuel to be economically and forcefully consumed. Naturally enough, plain mechanical considerations will always prevent an increase in the rotational speed beyond certain predetermined limits—but it is worth remembering that no more *power* would be required, frictional and efficiency considerations apart, to drive the compressor at the higher necessary speeds, since the compressor would still only be shifting the same weight of air and, consequently, doing the same amount of work.

* * *

One way or another the word "Brabazon," as applied to civil aircraft types, appears to have got a little out of hand. Perhaps because its manufacturers have been satisfied, in the early stages of its development, to give the largest of the Brabazon Committee's series of aircraft merely a type number, this aircraft appears to have been almost irrevocably labelled the Brabazon I. Yet there is no more reason for it to be so called than any one of the other recommended types. Perhaps, before the final rot sets in, it would be as well for someone in authority to clear up the situation. If we are going to be logical we might, along with the Bristol Brabazon, call the Airspeed Ambassador the "Brabazon 2a," the Miles Marathon the "Brabazon 5a," and the D.H. Dove the "Brabazon 5b."

At the same time, it might not be too bad an idea if, in any case, the "Brabazon type" situation could be cleared up at—to use that charming new expression—"official" or even "ministerial level." Perhaps, when it is possible to fill a few of the present gaps, we shall be given the firm and final series. At the moment the Brabazon 3 is thought to be a future jet or turbine-airscrew project in the 100,000 lb. size, while the 2b and 4 are almost unknown quantities. Contrary to previously accepted ideas, only the D.H. Dove amongst the present-day prototypes is a true Brabazon; the others are "intermediate" types to tide us over until the newer series of civil aircraft, based, perhaps, on the recommendation of the Committee, can be made.

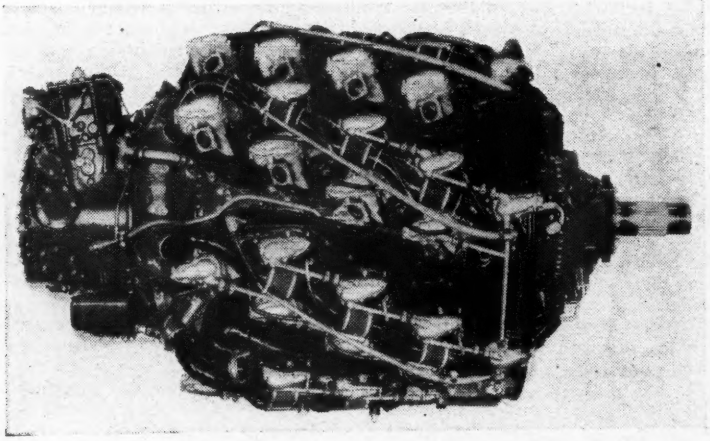
THE WASP MAJOR

MOST of America's new four-engined airliners, the eight-engined Hughes flying boat, and a number of military and naval types are being powered by the 28-cylinder Pratt and Whitney Wasp Major, which is reported to develop more than 3,650 h.p.

This big air-cooled multi-radial has four rows of seven cylinders and a total displacement of 4,360 cu. in. It has a dry weight of 3,405 lb. and is equipped with an automatically controlled, hydraulically driven, variable-speed supercharger and seven magnetos—one to each bank of four cylinders.

Other features include deep-finned forged aluminium cylinder heads and duralumin cylinder muffs designed for use on either tractor or pusher installations.

This engine, which has done over 17,000 hr. full-scale development running, first flew in May, 1942, and completed its 150 hr. qualification test in December, 1944.



This view of the new P. & W. Wasp Major clearly shows the helical arrangement of the 28 cylinders in four rows of seven each. The magnetos and distributors are on the reduction-gear casing, and the leads can be seen along the cylinder heads.

POWER JETS TO BE AN "ESTABLISHMENT"

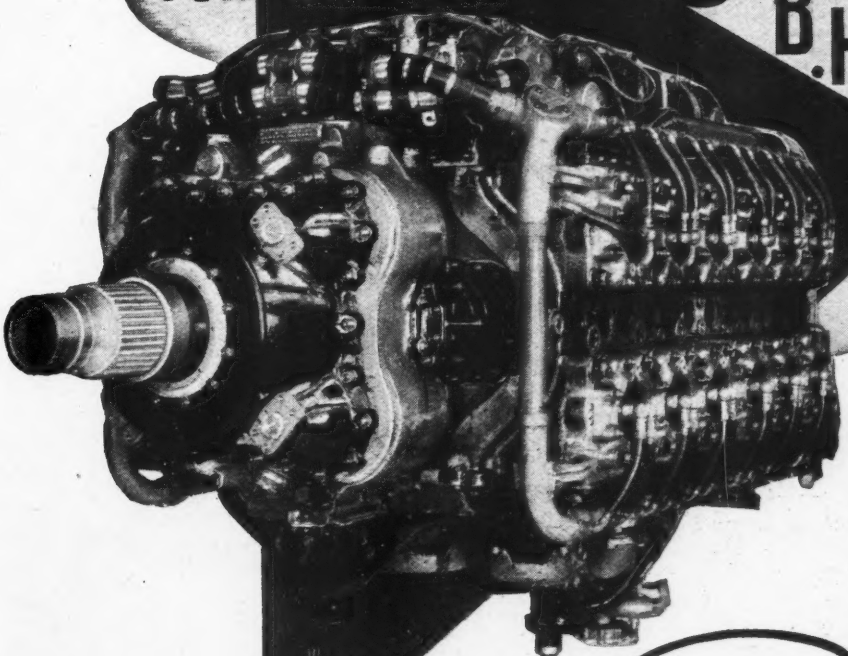
AN announcement by the Ministry of Aircraft Production states that Power Jets (Research and Developments), Ltd., is to be run as the National Gas Turbine Establishment, and that the present method of controlling it through the medium of a private company is to cease. The decision is one of Government policy and in no way reflects on the conduct of the company's business. The N.G.T.E. will now be on a footing similar to that of other Government "Establishments" such as the R.A.E., the Aeroplane and Armament Experimental Establishment, and the Marine Aircraft Experimental Establishment.

There is, as we go to press, no further official statement about the surprising resignation from the board of Air Commodore Whittle, but it is to be assumed that his knowledge and services will continue to be fully utilised in another capacity. It is understood that Whittle is desirous of developing complete aircraft and power units, instead of power units only.

TYPE TESTED AT

3000

FOR TAKE-OFF B.H.P



NAPIER "Sabre"

SERIES VII

D. NAPIER & SON LIMITED • LONDON • W.3

SALTER

The Spring of the Mighty

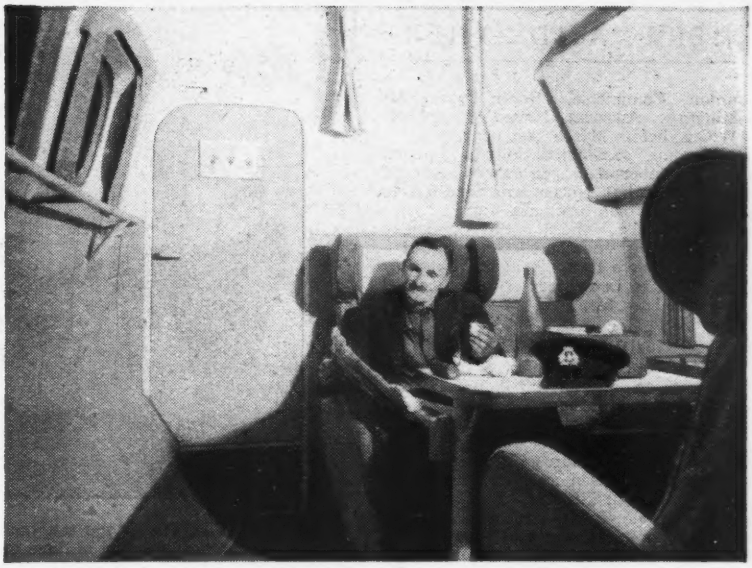
NAPIER

Engine

Geo. Salter & Co Ltd., West Bromwich
Makers of Precision Springs
Since 1760

M-W.113

HERE AND THERE



WOT, NO BRAZIER! The night-watchman on a B.O.A.C. flying boat in Poole Harbour may lack the traditional coke fire, but he certainly enjoys armchair comfort and is provided with a fire-proof oil heater when it is cold.

Insurance Much Cheaper

CUTS in personal accident insurance rates amounting to 75 per cent. with added cover have been announced by Railway Air Services, West Coast Air Services, Isle of Man Air Services, and Great Western and Southern Airlines, thanks to their safety record in civil air travel.

As against a purely travel risk premium of 8s. for £1,000 cover over 24 hr., all their air booking offices can now offer a comprehensive "all risks" cover for the same period at a premium of 2s. per £1,000.

At the Science Museum

THE Exhibition of German Aeronautical Developments, which opened in the Science Museum at South Kensington a week ago, should give to the general public an instructive glimpse of the enemy's past activities in this sphere.

The exhibits are taken from the comprehensive display of British and German aircraft and equipment held at the Royal Aircraft Establishment, Farnborough, last year (described in *Flight*, Nov. 1st, 8th and 15th.), but it has only been possible to find space at Kensington for five complete German aircraft, plus a selection of various kinds of equipment.

A Derwent and a Goblin jet engine have been included to provide comparison with German contemporaries, and the exhibition, which has been well attended so far and is to run for three months, is admission free. Hours are 10 a.m. to 6 p.m. on weekdays and 2.30 p.m. to 6 p.m. on Sundays.

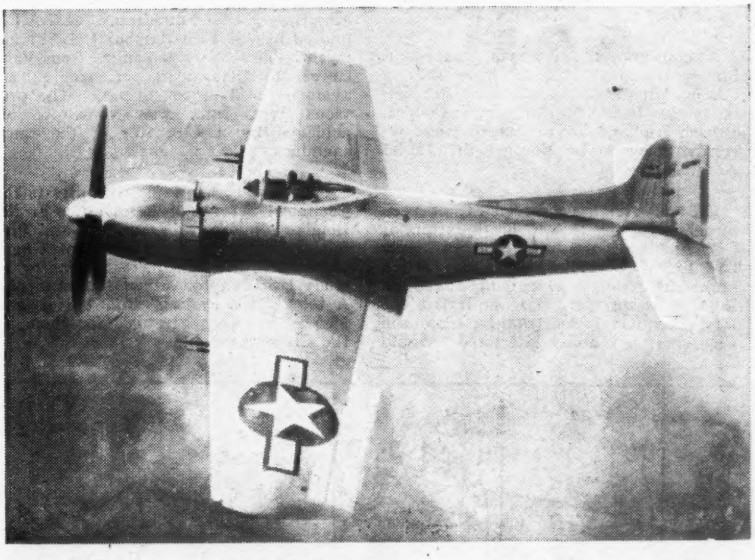
"... *and See his Children Fed*"

YOU may remember that the above words ended the simple little poem about "Johnny in the Clouds" written by the squadron-leader in that magnificent film, "The Way to the Stars."

It expresses, with equally simple sincerity, the idea behind the R.A.F. Pilots' and Crews' Fund for "The Few," raised by the Institute of Auctioneers and Estate Agents, which has reached a total of £352,950.

A summary of grants published in the Institute's journal shows how the money is distributed—the maintenance of children, medical benefits, and so forth.

Midlanders may feel justly proud that among the Institute's 18 local branches, Birmingham and the West Midlands easily heads the list with a contribution (up to January 18th) of £63,184, while the Midland Counties branch comes second with £35,861.



NEW TORPEDO DIVE BOMBER: A flying view of the Martin Mauler designed for operation with carriers of the *Midway* class. Top speed of 350 m.p.h., a range of 1,700 miles and ability to dive vertically at over 500 m.p.h. are claimed.

FORTHCOMING EVENTS

Feb. 21st and 22nd.—Royal Aeronautical Society*; lectures on "The Development of the Internal Combustion Turbine," by H. Constant and associated authors at Power Jets and the R.A.E. (morning and afternoon sessions).

March 1st—†Akroyd-Stuart Lecture, Nottingham.

March 4th.—†James Clayton Lecture, Newcastle.

* At the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

†Lectures by Air Comdre. F. Whittle.

Halton's Silver Jubilee

THE social reunion of ex-Halton aircraft apprentices originally planned for December last to mark the 25th anniversary of the training scheme is to take place in the Royal Horticultural Society's old hall in Vincent Square, Westminster, W.1, on Monday, April 8th next, from 6 p.m. till 11.30 p.m.

All who have served or are still serving on the staff at Halton (including civilians) are invited to attend this gathering and applications should be accompanied by a cheque or Postal Order for 5/- made out to "The Halton Society, Lloyd's Bank, Strand, W.C.2," and sent to the Secretary, Halton Re-

HERE AND THERE

union Committee, Room 771, Air Ministry, Adastral House, Kingsway, W.C.2, before March 21st next.

Sleeping accommodation in London for a number of airmen can be arranged on request but officers are expected to make their own arrangements.

Incidentally, those who previously applied—they numbered some 1,200—will now have to apply again, but they may like to know that a fully licensed bar has been arranged.

"Mlle. Pimpernel"

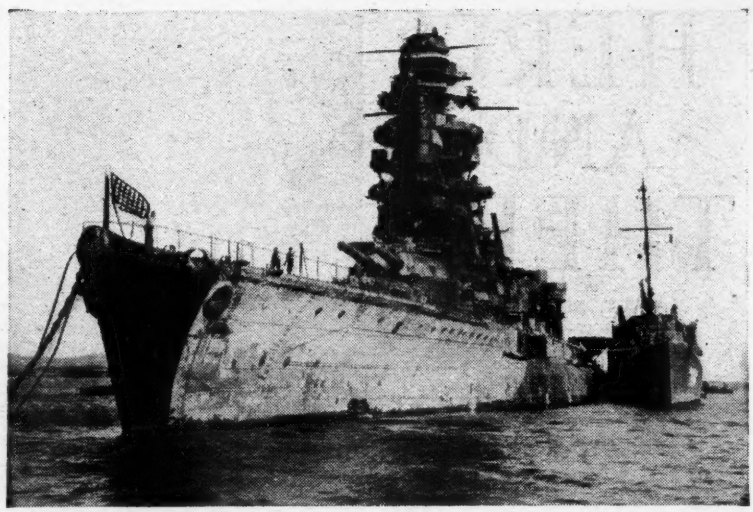
MANY an R.A.F. pilot and member of an aircrew owed his liberty, after baling out over German-occupied Europe, to the 25-year-old Belgian girl whose photograph appears below.

She is Mlle. Andree de Jongh, who, for some eighteen months during the war, helped all kinds of Allied airmen—nearly 1,000 in all—to get back to England from Belgium and France, until she was finally caught by the Gestapo and sent to a concentration camp.

Viscount Stansgate presents the bomber's clock to Mlle. Andree de Jongh.

She made no fewer than 34 journeys across France and over the Pyrenees in all weathers, and one day swam a river 20 times to get her charges safely across.

Last week this modern "Mlle. Pimpernel" was deservedly awarded the George Medal by the King, and was presented with a bomber's clock by Lord Stansgate, Secretary for Air, on behalf of the R.A.F.



TEST TARGET: The 32,730 ton Japanese battleship, *Nagato*, is one of the fleet of 97 vessels on which the first of three tests with atom bombs will be made in May.

News in Brief

AN R.A.F. exhibition was opened in Zurich last week by Air Marshal Sir Arthur Coningham. The ceremony was attended by Dr. Karl, President of the Swiss Federal Council, and popular interest has been centered mainly in a Spitfire which the townspeople were seeing for the first time.

* * *

Group Capt. A. V. R. ("Sandy") Johnstone, a former leader of No. 602 (City of Glasgow) Fighter Squadron, has been appointed Air Attaché to Eire and takes up his new duties this month.

* * *

Maj. Gen. K. N. Crawford, who has been Director of Air at the War Office since 1942, has been appointed G.O.C. British Troops in Greece in succession to Lt. Gen. Sir Ronald Scrobie, and takes the acting rank of lieut. general.

* * *

A consignment of books, part of a library of 2,000 volumes from Belvoir Castle, presented to the British Embassy in Paris by Mr. Duff Cooper, British Ambassador to France, were recently flown to Le Bourget in a Miles Aerovan.

* * *

Officers who have served at, or been attached to, the R.A.F. headquarters at Gillingham, Kent, during the war, may like to know that Flt. Lt. E. Dicken hopes to arrange a reunion dinner in London at an early date and that the formation of an association has also been suggested. Those interested should write to Flt. Lt. Dicken at Gillingham and give their present addresses.

* * *

Air Vice-Marshal Sir Edward Rice, former A.O.C. in West Africa, arrived recently in India to take over the post of Deputy Director Aircraft (India). Air Comdre. Edward I. Bussel, the new Director of Training and Licensing, also arrived on the same day.

* * *

Prince Bernhardt of the Netherlands recently decorated Marshal of the R.A.F. Sir Sholto Douglas with the Knight Grand Cross of the Order of Orange-Nassau (with sword), in the Royal Palace of Soestgyt. This is Sir Sholto's twentieth decoration and the seventh from a foreign country.

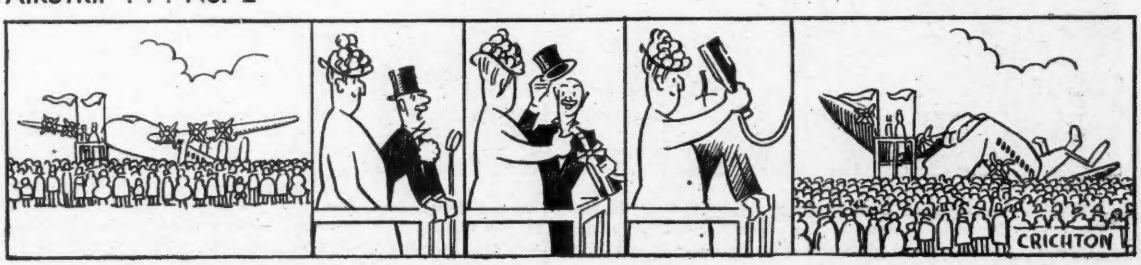
* * *

A Flying Fortress of No. 168 Transatlantic Mail Squadron, R.C.A.F., piloted by Air Vice-Marshal J. L. Plant, recently flew the 2,300 miles from Vancouver to Ottawa in 7hr. 26min., an average speed of 305 m.p.h. The previous best time was 10hr. 52min. achieved by a Liberator of the same squadron.

* * *

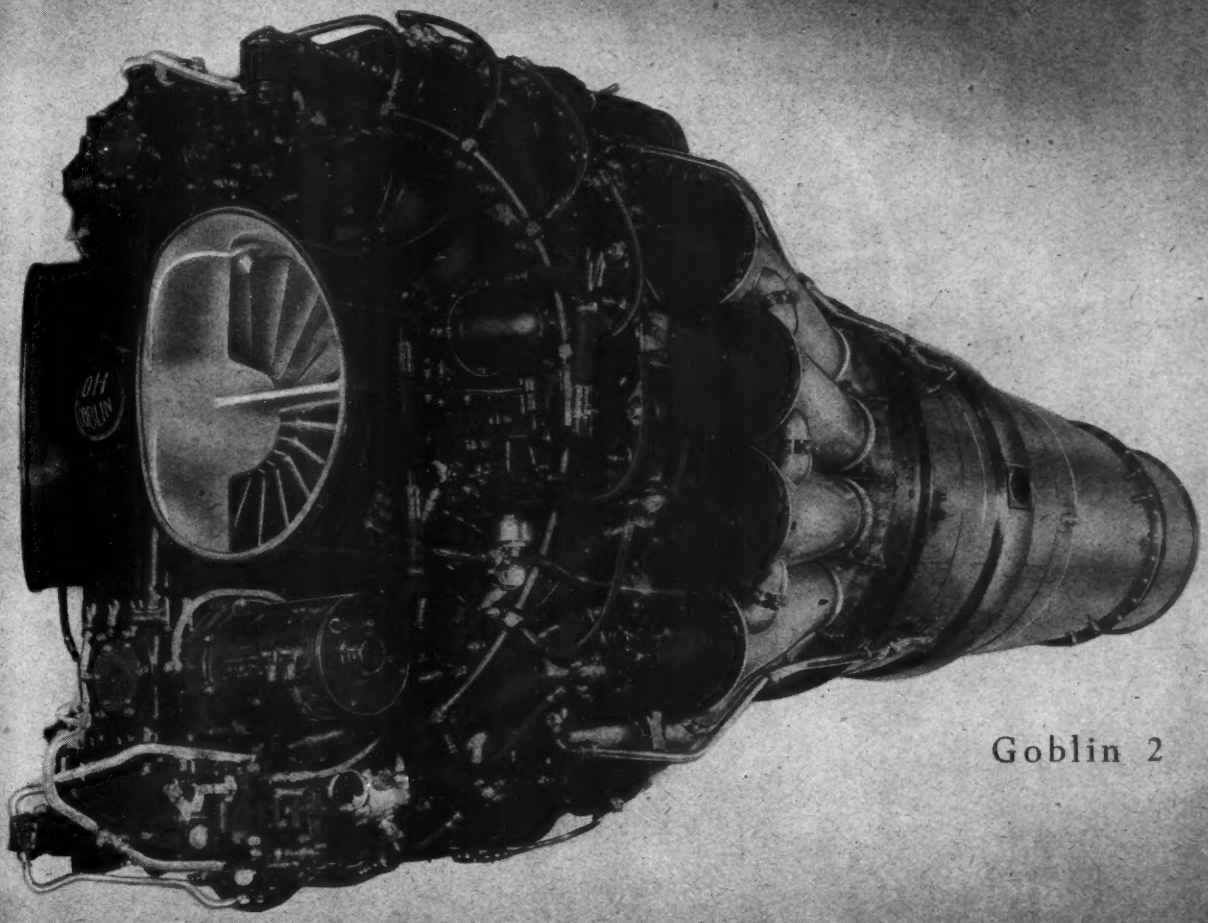
Professor F. C. Haus, who directs the Technical Service of Aeronautics at the Belgian Ministry of Transport, and Professor F. P. A. Malschaert, of Ghent University, are visiting this country to study British aeronautical developments. A tour of the leading aircraft firms and M.A.P. has been arranged for them by the British Council.

AIRSTRIP . . . No. 2



FLIGHT
Feb. 21,
1946.
Advt. i.

Power plant of the fastest single-engine fighter in the Royal Air Force



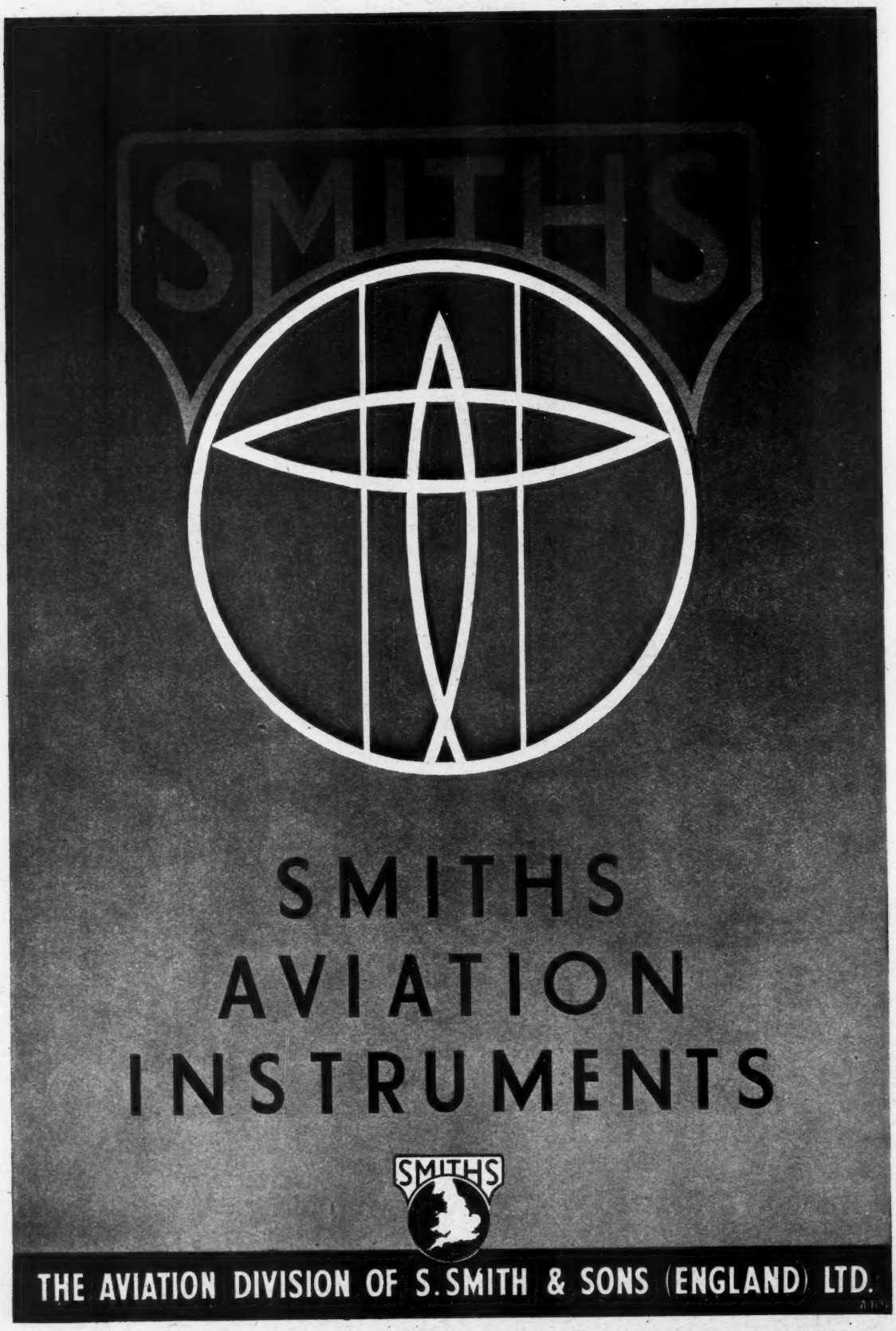
Goblin 2

DE HAVILLAND

high-efficiency

JET ENGINES

DH ENGINES


SMITHS
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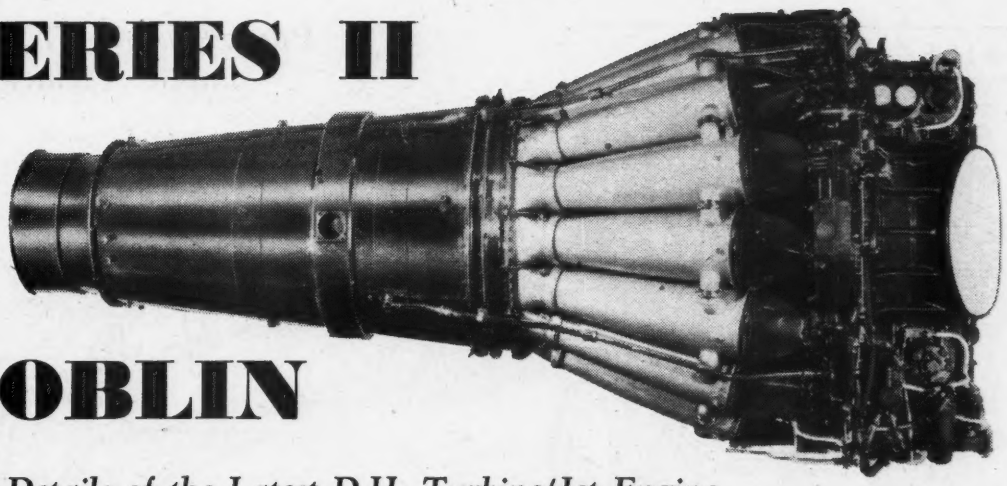
THE AVIATION DIVISION OF S. SMITH & SONS (ENGLAND) LTD.

SERIES II GOBLIN



Full Details of the Latest D.H. Turbine/Jet Engine

IN the issue of *Flight* dated November 1st, 1945, the Goblin turbine/jet engine was introduced together with those chiefly responsible for its design, namely, Major F. B. Halford and Messrs. J. L. P. Brodie and E. S. Moult. The layout of the Goblin, and its descent from early Whittle designs, was at that time described, and the shipping of units to America for the Shooting Star was also recorded. It is now permissible to describe in detail the construction of the Goblin II and to give the full performance figures and running conditions.

When the design was first considered in 1941, one of the most important considerations was the time element. A turbine/jet engine was needed quickly, and anything likely to prolong the development, or unduly complicate the manufacture, had to be avoided. Under different circumstances, an axial-flow compressor and a single annular combustion chamber might have been developed for the first D.H. unit. However, both of these, while theoretically superior, were in the nature of unknown quantities, lacking in practical data and, in addition, there was already some foundation for the belief that axial-flow compressors were proving something of a headache to German manufacturers.

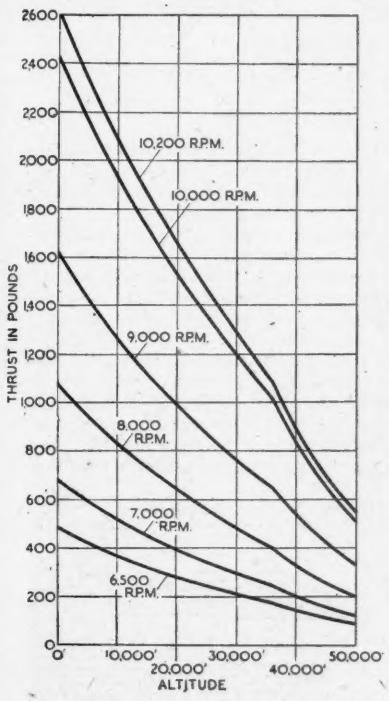
With regard to combustion research, a similar position existed; a fair amount was known about small individual combustion chambers but practically nothing of the single, large annular type. As a result, ideas for the truly "straight-through" design were for the time being set aside, and components were selected of a type for which practical performance figures would be available, namely, radially arranged combustion chambers of the accepted type and a compressor impeller basically similar to that for, say, a piston-engine supercharger.

One of the principal differences between the Goblin Series and other units is, of course, the use of a single-sided impeller for the centrifugal compressor. While it was fully realised that a double-sided impeller, as favoured by Whittle, appeared to make possible a unit with smaller overall diameter, and that a large-diameter impeller, besides being more limited in rotational speed, would raise some problems in manufacture, the D.H. design staff felt that there was a balance in favour of the single-sided design.

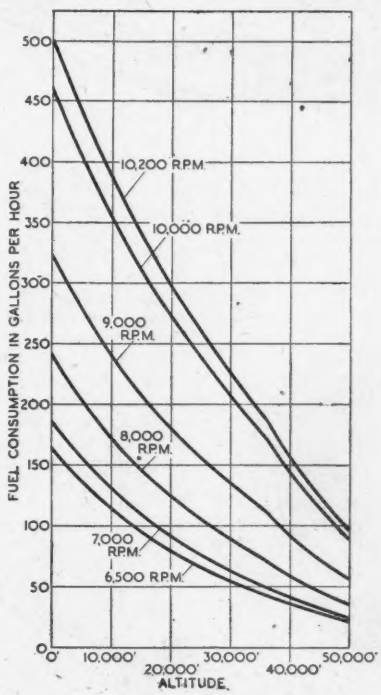
Direct Air Intake

In particular, the greatest possible use could be made of an uninterrupted direct air flow to the eye of the impeller through a large intake. Ram effect could be employed to the full, and eddy and friction losses were likely to be very small.

In addition, it was felt that while a double-sided impeller made possible a compressor of smaller diameter for a given capacity, this advantage was to a great extent offset by the need to provide annular air passages around the outside of the compressor between combustion chambers, for the supply of air to the rearward-facing intake, and by the resulting less compact arrangement of the combustion chambers. It was also argued that the rear intake itself, with a 180-degree turn in the air flow, seemed likely to



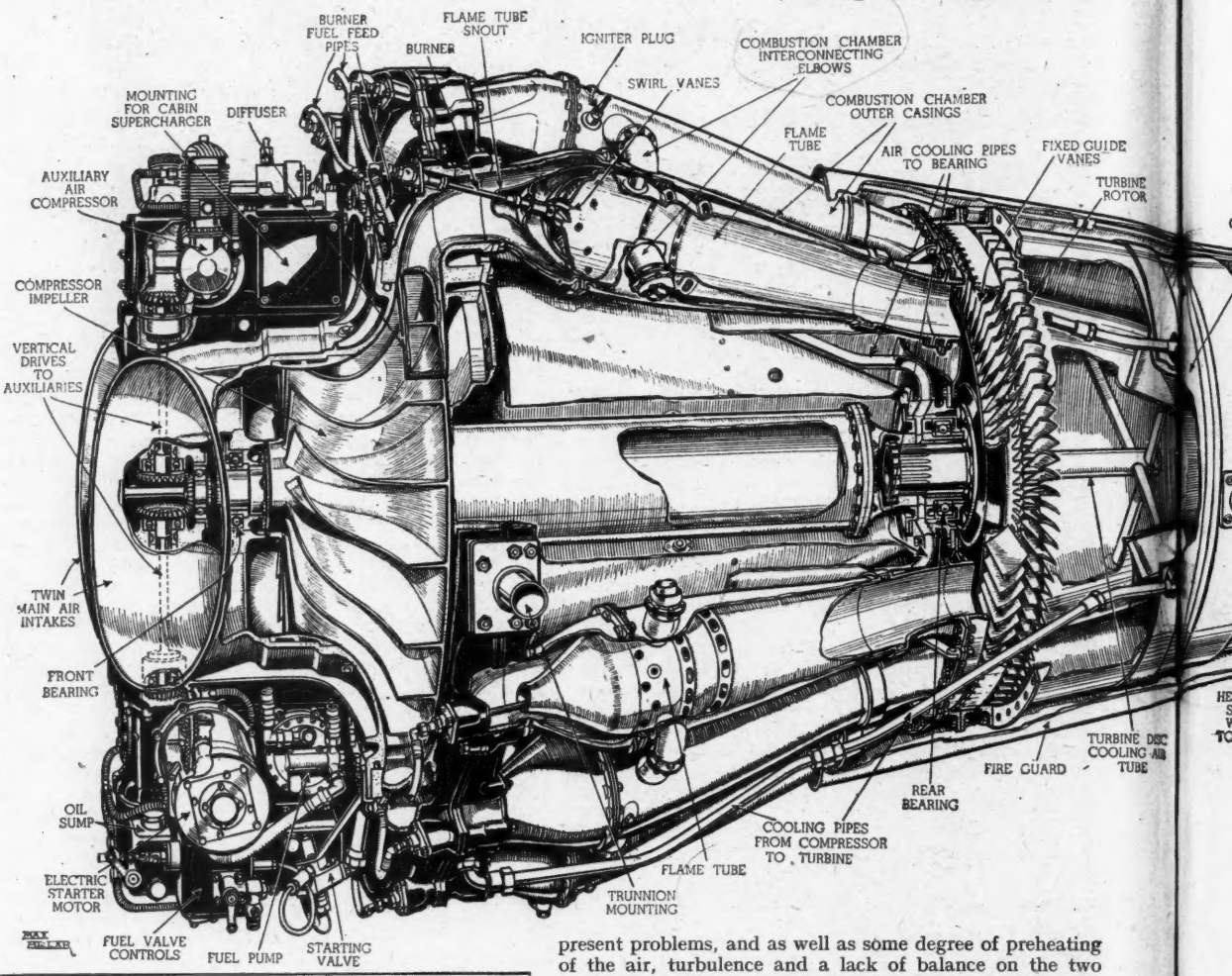
The variation of thrust with altitude, at 500 m.p.h.



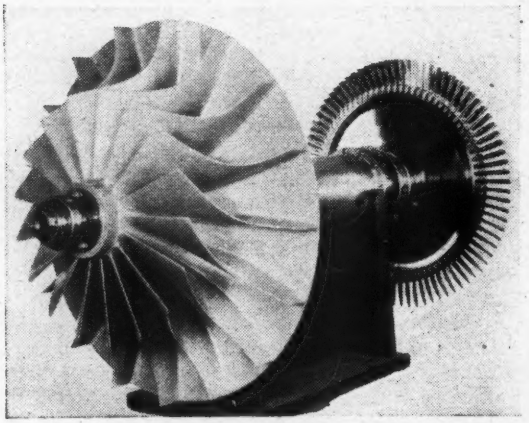
The variation of fuel consumption with altitude, at 500 m.p.h.

SERIES II GOBLIN . . . .

Power Unit of the Vampire Fighter



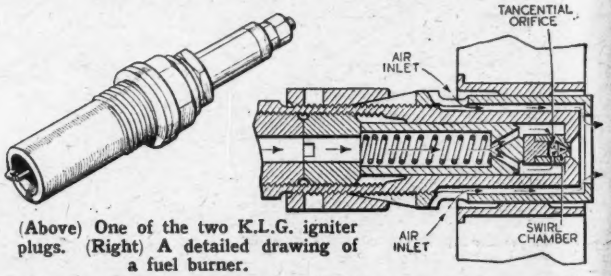
CONSTRUCTIONAL details of the D.H. Goblin II are revealed for the first time in this special sectioned drawing of the complete unit. ("FLIGHT" copyright).



The large single-sided one-piece impeller shown as a unit o the main rotating assembly.

present problems, and as well as some degree of preheating of the air, turbulence and a lack of balance on the two sides of the impeller would arise. A certain compromise in design, tending to restrict breathing, was foreseen.

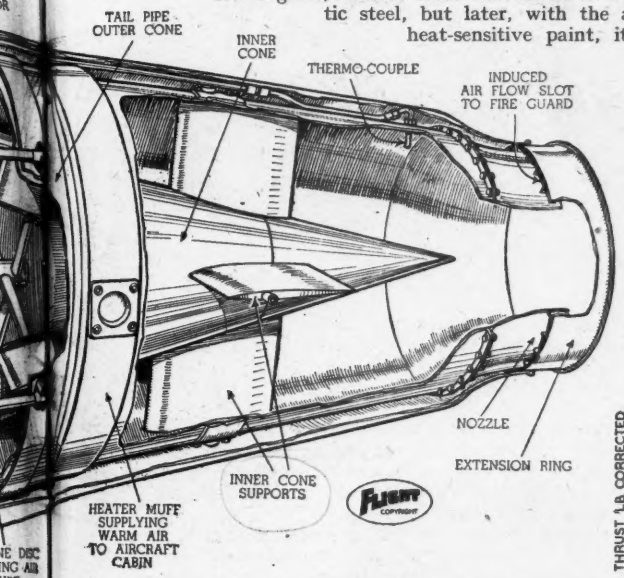
For a unit with a single-sided impeller, two more advantages are claimed; first, that the inherent simplicity and compactness permits the use of only two bearings for the main rotating assembly, as compared with three required with a double-sided impeller; and secondly, that the axial load component on the turbine blades can be almost balanced by the forward-acting thrust-loading on the impeller. The degree of unbalance is governed, within limits, by the positioning of the fourteen labyrinth sealing rings on the back of the impeller, and at present the component of the pressure acting forwards on the impeller rear face is equal to 20 lb./sq. in. A final consideration in selecting



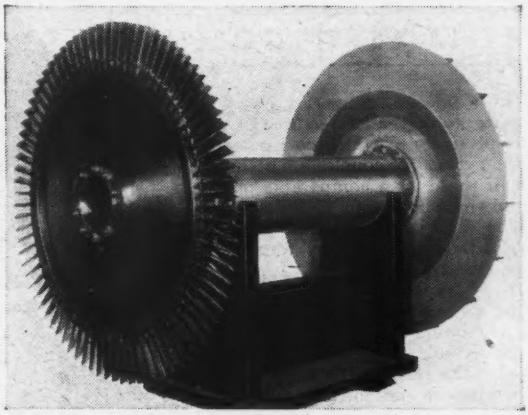
(Above) One of the two K.L.G. igniter plugs. (Right) A detailed drawing of a fuel burner.

the single-sided impeller was that the resulting complete power unit suited the layout of the Vampire, for which it was intended, thus fulfilling a point of D.H. policy: the building of engines to suit the aircraft.

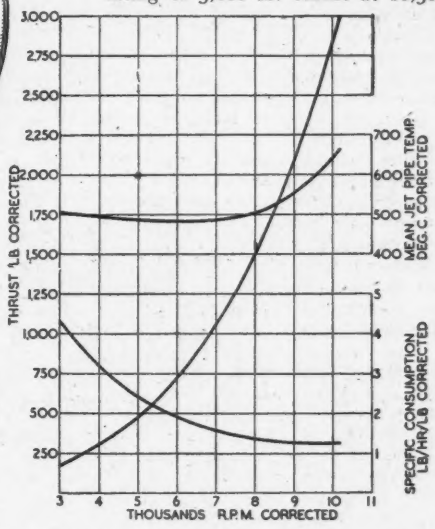
Before production of the Goblin prototype could begin, there remained one more problem to settle, namely, the detail design and selection of materials for the turbine disc and blades. Plenty of theoretical information was available on blade form, but little was known about the operating temperatures likely to be experienced. Chief properties required of the selected materials were a high resistance to creep, corrosion and scaling. On the first few engines, turbine discs were made of austenitic steel, but later, with the aid of heat-sensitive paint, it was found that ferritic steels with their greater strength, around the working temperature of 750 deg. C. and a lower coefficient of expansion, would prove satisfactory. Operating temperatures and materials which now apply to the Goblin are given on page 190.



The first test run by a Goblin was made in April, 1942, and preliminary troubles experienced included weaknesses in the welding of combustion chambers, and in the construction of the intake ducts and the tail pipe. By June, after eighteen months' work, the Goblin was tested up to its designed rating of 3,000 lb. thrust at 10,500 r.p.m. The tailpipe temperature was around 620 deg. C. and the specific fuel consumption 1.233 lb./lb. thrust/hr.



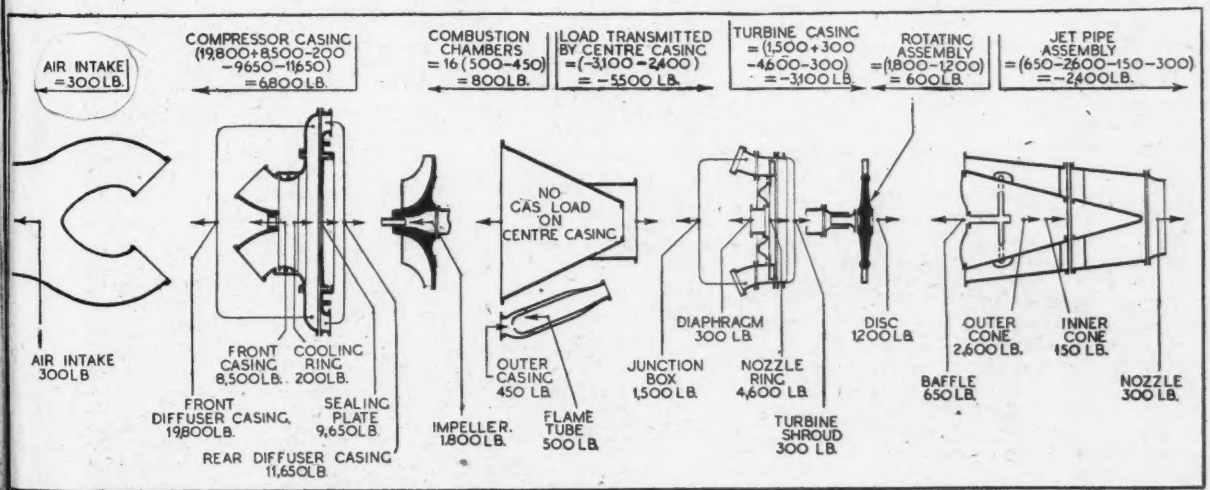
The main rotating assembly viewed from the turbine disc or rear end.


THRUST LB CORRECTED
MEAN JET PIPE TEMP. DEG.C CORRECTED
SPECIFIC CONSUMPTION LB/HR/LB CORRECTED
THOUSANDS R.P.M. CORRECTED

Typical curves taken for a Goblin on 100 hr. type test at 3,000 lb. thrust rating.

The Goblin II is substantially similar to earlier units already described in *Flight*, but it will be well to recall details of the components and to add later information.

A single-stage, single-entry centrifugal compressor provides an air flow of 60 lb. per second at maximum operating speed. The power required to drive the compressor is a little under 6,000 h.p. and the pressure-ratio and temperature-rise be-



Component axial loads under static conditions at sea level. The net thrust may be seen to equal 3,000 lb. at the engine mountings.

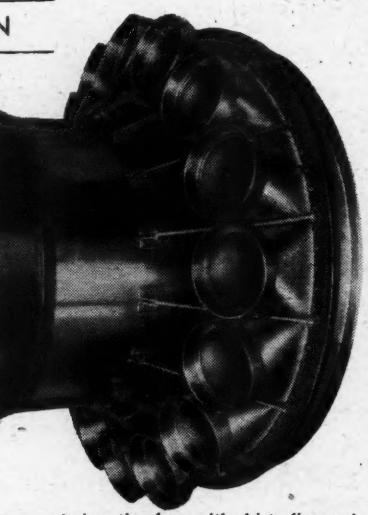
SERIES II GOBLIN

tween inlet and delivery approximate to 3.5 and 150 deg C. respectively. At 10,500 r.p.m., the gyroscopic couples are about half those for a comparable piston engine/airscrew installation. The impeller is a one-piece, heat-treated light-alloy forging, anodised and polished. It is thirty-one inches in diameter, has seventeen vanes and reaches a maximum tip speed of 1,430ft. per second.

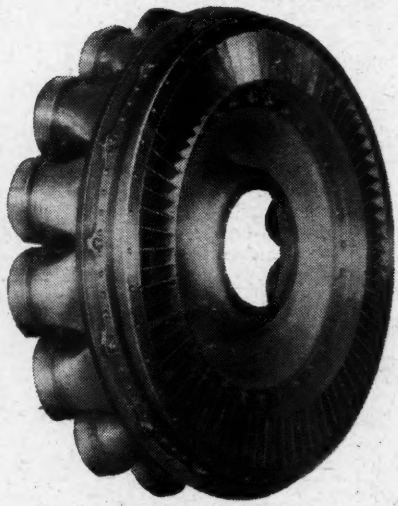
On the back of the impeller a number of concentric labyrinth grooves (the number has been increased in later Goblins) match up with similar grooves on the sealing plate at the back of the compressor unit.

The gas turbine which provides driving power for the compressor and auxiliary drives is of the single-stage axial-flow type. It has seventy-seven stator blades and eighty-three rotor blades; numbers having no common denominator to avoid resonance. Tip diameter is about 27 in. and the blades, tapering slightly from root to tip, vary between 1.3 and 1.1 inches in width. Under operating conditions the centrifugal stress at the blades is nine tons per sq. in. and the maximum gas bending stress is 12.5 tons per sq. in. The constructional material, Nimonic 80, is an alloy with very high nickel content. The creep limit in the ferritic steel turbine disc is 0.1 per cent., but this has not in fact been approached on components checked after the 300 hours' running period.

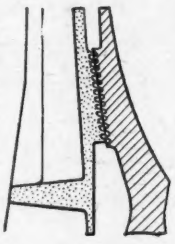
The moving blades are attached to the turbine disc by the "fir tree" method, that is, evenly spaced serrated slots are broached in the periphery of the turbine disc and the roots of the blades bearing corresponding serrations are slid axially into the slots. The blades are held in position by peaning at the roots on each side. On the upstream side the peaning is a little heavier to resist rearward thrust. Illustrations of the blades and the slots in the turbine disc appear on page 189.



The nozzle junction box with skirt, diagonal stays, and combustion chamber seatings.



The fixed nozzle ring assembly showing the diaphragm for radial location.



Compressor labyrinth sealing rings.

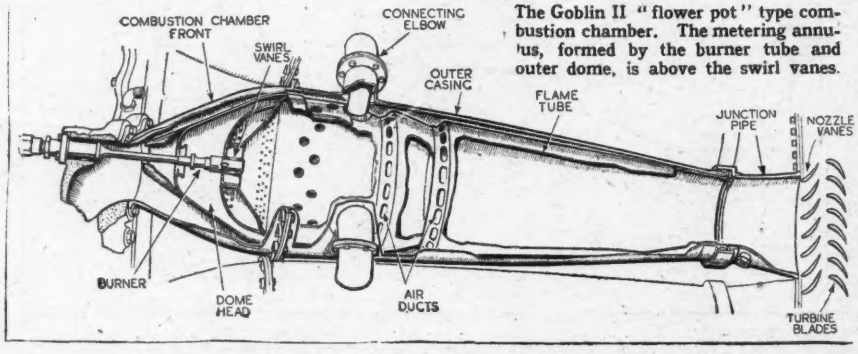
Bolted to the turbine and the impeller, the large-diameter centre shaft is machined from a steel forging, and these three components form the main rotating assembly which is carried in two ball bearings. Any thrust loading is taken by the front bearing which is located on a stub or pivot shaft between the air intake ducts in front of the impeller. This stub shaft is shrunk into and bolted on to the impeller and all the bolts for the attachment of both stub and main shafts pass through tubular dowels which take all shear loading, the studs being in tension. Drives for the auxiliaries are taken from the stub shaft through bevel gears.

The rear bearing is fitted in a special sliding housing and is designed to take only journal loading. It is air cooled, carries a heat insulating plate, and runs at a temperature of about 130 deg. C. The cooling-air circuit and the lubrication is described later.

Turbine and impeller are first balanced separately and then as a unit. The limits permitted are respectively 5 and 7.75 grm. inches, and subsequent measurements of vibration for the whole power unit have shown that the vertical oscillation is less than ± 0.001 inch.

Improved Combustion Chambers

Sixteen combustion chambers are fitted to the Goblin series units, and on the Goblin II these are of "flower pot" design as illustrated on this page. They comprise a flame tube and an outer casing—each of which is made in two basic sections—and a burner. With the primary part of the flame tube, the fuel burner forms an annular space through which passes a metered quantity of air, sufficient for primary combustion. The metering annulus is, in fact, located in the outer dome, between the "Snout" and inner dome, and approximately one quarter of the air to the combustion chamber passes through it. The air for primary combustion also passes through swirl vanes which promote a back vortex round the flame. As a result, the inrush of air helps to promote flame stability instead of blowing the flame out. In addition, a small quantity of air which passes round the outside of the swirl vanes through holes in the inner dome and flared cover plate, produces enough outer turbulence to mix the fuel and air.



The Goblin II "flower pot" type combustion chamber. The metering annulus, formed by the burner tube and outer dome, is above the swirl vanes.

The remaining bulk of the intake air is admitted to the flame tube in stages as it passes round between tube and outer casing. Its purpose is dilution and cooling of combustion gases which, from an initial 2,000 deg. C. near the burner, enter the turbine blades at not more than 790 deg. C. Combustion is completed within one-third

FLIGHT,
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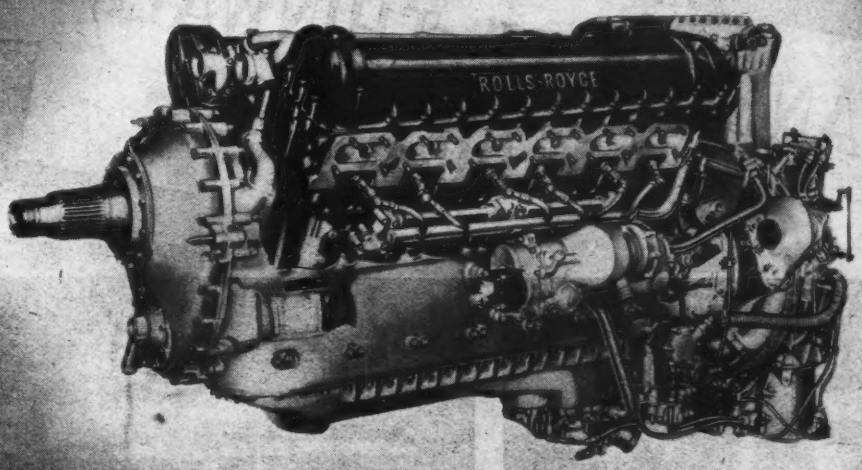

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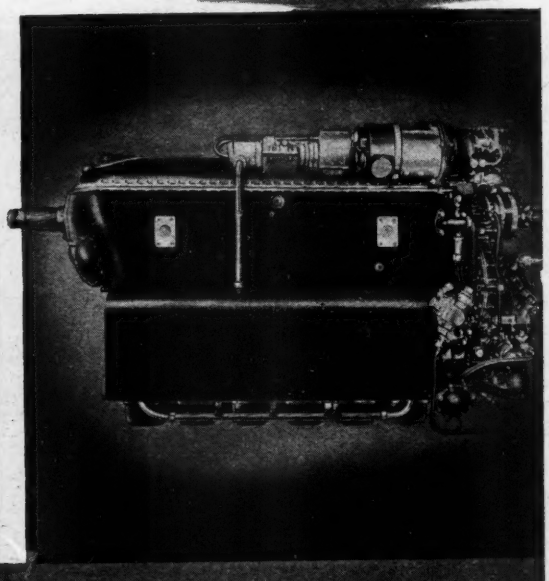

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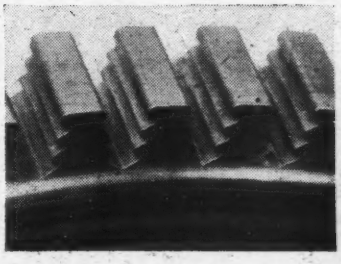
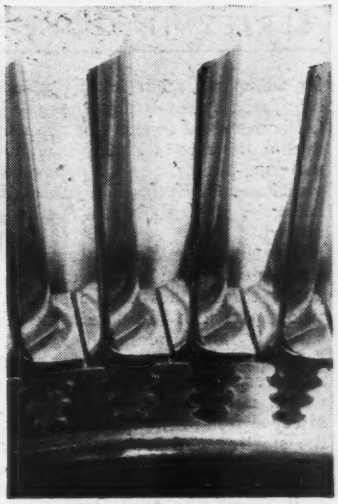
Simee's

SERIES II GOBLIN

of the length of the tapered section of the flame tube.

With regard to the fitting of combustion chambers, the top end is in each case bolted to a small light-alloy expansion chamber, and this is in turn bolted to the diffuser casing. At the lower end, to allow for expansion, there is a piston-ring joint where the outer casing slides into a seating in the nozzle junction box. The flame tube inside the combustion chamber is a loose sliding fit at its tapered down-stream end and it is positioned by six small depressions. At the top, it is located by three equally spaced radial pins registering with sockets on the flame tube. Interconnecting passages, made up of inner and outer tubes, maintain a balance of pressure between individual combustion chambers.





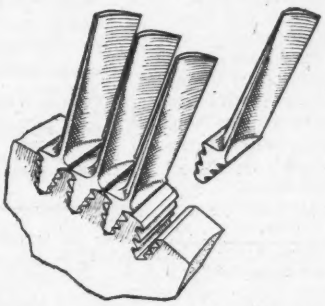
(Above) A section of the turbine disc with serrated slots prepared to receive the blade roots shown in position in the illustration on the right.

The Static Structure

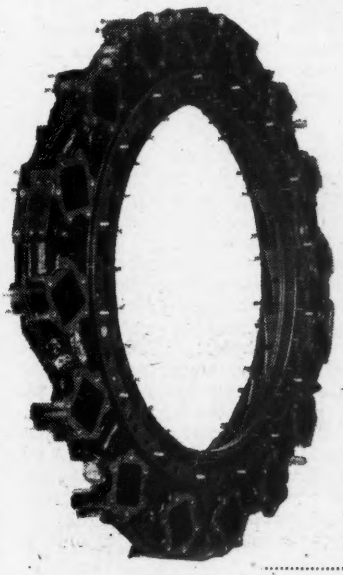
The main frame or static structure of the Goblin comprises the compressor front casing with twin air intakes; the two-piece diffuser casing; the conical centre casing with skirt, and the nozzle junction box assembly with diaphragm plate and turbine bearing housing. Constructional materials for all main components are given in tabular form on page 190. The components are bolted together to form a rigid backbone for the power unit, and the nozzle box assembly is further supported by diagonal stays to the centre casing which isolate thrust, torque and bending loads from the combustion chambers.

A recent modification is the ribbing of the compressor rear sealing plate which had previously shown signs of panting due to insufficient stiffness.

The diffuser casing is made in two halves and carries the passages and pipes for supplying cooling air to the rear bearing and turbine. There are two separate cooling-air systems but the air for each is taken from the main supply from the compressor. The turbine rear face is cooled by an air stream between the disc and rear baffle plate. Air is taken from four points in the rear diffuser casing near the tips and is led in separate pipes through the streamlined inner cone supports to the back of the turbine. For the turbine bearing and front face air is supplied through holes in front of the diffuser casing, and is led through pipes to a cooling ring in the main air intake casing. From this point the cool air is led to the turbine sliding bearing and finally flows up the front face of the turbine disc which is thus cooled on both sides.



"Fir tree" turbine blade attachments. Also illustrated at the top of the page, the blade roots are lightly peaned to hold them in position.



The diffuser casing is a magnesium casting made in two halves. Vanes, cooling-air pipes and passages, and expansion box seatings may be seen.

The cooling ring mentioned is sweated into the intake casting at an early stage and is machined down to give a perfectly smooth duct interior. Its presence can only be detected by an enlarged band on the outside of the casing and by the pipes leading to it.

Bolted to the rear bearing housing is a deep-drawn stainless steel diaphragm plate which gives radial support to the static part of the turbine assembly. The main components of this assembly are the nozzle junction box, the fixed nozzle ring and stationary turbine shroud. The method of attaching the stator blades by two pins to their inner ring and by a single peg to their outer ring is illustrated on page 190; the outer ring is split into segments to allow for expansion.

After leaving the turbine, the combustion gases pass through the tapering jet pipe to the propelling nozzle. Supported by four 90-degree streamlined stays in the jet pipe is the inner cone or bullet, and around the jet pipe, in two main sections, is the lagging or outer muff. Between muff and jet pipe is a narrow space through which flows air for heat insulation; the air is also available for aircraft heating purposes.

Normally, fuel is supplied by an engine-driven pressure pump of the rotary type, having seven plungers reciprocating in a cylinder block rotating round a central stationary shaft. The pump is rated at 650 gal./hr. at a pressure of 800 lb./sq. in. at 3,500 r.p.m. This corresponds to an engine speed of 10,500 r.p.m. Before delivery the fuel passes through a control box containing a metering orifice the area of which is controlled by a tapered needle operated from the pilot's throttle lever. The contour of the needle is arranged to provide a roughly linear relationship between engine thrust and throttle lever travel. A barostat automatic altitude control gives a constant engine speed, without manual adjustment, between sea level and 38,000ft.

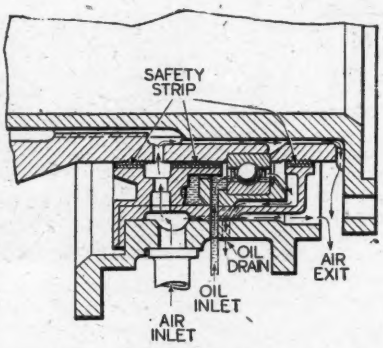
The fuel used is aviation kerosene, which has a specific gravity of 0.05 at 15 deg. C.; a net calorific value of 10,310 C.H.U. per lb.; a freezing point of −40 deg. C.; a flash point of 30 deg. C.; and a spontaneous ignition temperature of 450 deg. C.

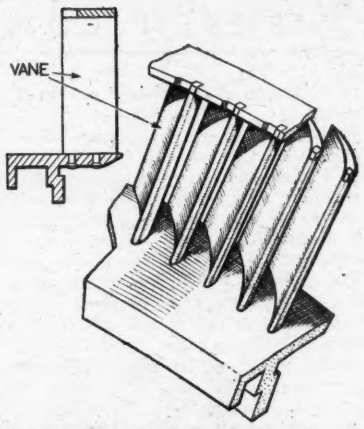
Oil is delivered by a gear-type pressure-pump at 50 lb / sq. in. The sump has a capacity of 12 pints, and is mounted on the front casing with the accessories. All accessory drives are carried in ball bearings and some 90 gallons of oil per hour are delivered to the auxiliary drives

SERIES II GOBLIN

for which the main driving gears are lubricated by seven high-pressure jets. Oil is delivered to the two main bearings at the rate of ½ pt. per hour, via metering pumps, and the pilot receives visual warning if the oil pressure drops below or rises above the limits permitted.

The starting cycle is automatic, and the motor, which is geared to run at about three times engine speed, develops 9-12 h.p. To obtain the necessary air flow, the impeller must be turned at 900 r.p.m., and for satisfactory acceleration to idling speed, 1,500 r.p.m. is required. After closing the safety switch in the cockpit to energise the starting and fuel booster pump circuits, the starting sequence is as follows: With throttle lever at the slow-running stop, and high-pressure fuel distribution valve set at "open," the starting button is pressed. The motor is initially energised through a high-resistance which keeps the speed down, and permits shock-free engagement of the starter dogs. After some six seconds, a time switch cuts out the resistance, and the motor accelerates until 600 r.p.m. is indicated for the engine. During the next seventeen seconds, the engine pump charges the fuel accumulator to the starting pressure of 40 lb./sq. in. and the spring-loaded diaphragm of the automatic starting valve is then forced off its seat and held in the open position by a mechanical catch. Fuel is now permitted to flow to the burner ring, and as soon as a pressure of 5 lb./sq. in. has built up, the automatic pressure switch is pressed, and full current is supplied to the starting motor. The starter motor now increases the indicated r.p.m. to about 1,500 during the next 13 seconds, and the two igniter plugs, fitted with their electrodes across the fuel spray, light up the fuel in the combustion chambers, the flame travelling quickly round to the other combustion chambers through the connecting pipes.





(Above) Details of the sliding rear bearing. (Right) The fixed nozzle blades are secured by two pins and one peg.

CONSTRUCTIONAL MATERIALS

Compressor impeller	R.R.59 (L.42), drop stamping from continuous cast ingot (silicon 0.25 per cent. maximum)
Turbine rotating blades... ...	Nimonic 80, individual drop stampings
Turbine disc	Hecla 153, or Jessops H.3.A, drop stamping
Nozzle blades	Jessops G.18B, or Nimonic 75, drop stamping
Nozzle inner, outer, and shroud rings	H.R. Crown Max. centrifugally spun castings, annealed
Junction pipe	Inconel from sheet
Nozzle assembly bolts	D.T.D.176A austenitic steel (with S.80 nuts)
Combustion chamber front outer casing	Aluminium alloy D.T.D.272, annealed, die casting
Combustion chamber rear outer casing	Mild steel deep drawing, protected by nickel plating
Combustion chamber flame tube	Inconel from sheet
Centre casing	Stainless steel (F.D.P.) from sheet
Jet pipe assembly	F.D.P. from sheet
Diffuser and front casing ...	Magnesium alloy (D.T.D.281), castings annealed

D. H. GOBLIN II—Performance, Design Data and Dimensions
10,200 r.p.m. Static Sea-level Conditions

Fuel flow	3,720 lb/hr. (465 gal/hr.)
Maximum fuel pump delivery pressure	900 lb/sq. in.
Blower pressure ratio (overall)	3.3 to 1.
" " " (intake-delivery)	3.75 to 1.
" temperature rise	150 deg. C.
" horsepower	5,720
Air mass flow	60 lb/sec.
Air fuel ratio	58 to 1.
Turbine inlet temperature	790 deg. C.
Jet velocity	1,610ft/sec.
Maximum jet pipe temperature	685 deg. C.
Cruising jet pipe temperature	550 deg. C.
Climbing jet pipe temperature	630 deg. C.
Maximum rear bearing temperature	130 deg. C.
Oil consumption maximum, all conditions	1.5 pt/hr.
Normal oil pressure (cruising)	40/45 lb/sq. in.
Oil tank capacity	12 pints.

Performance

Maximum static thrust	3,000 lb. at 10,200 r.p.m.
Cruising static thrust	1,850 lb. at 8,700 r.p.m.
Idling static thrust	150 lb. at 3,000 r.p.m.
Maximum burner pressure at take-off r.p.m. ...	650 lb/sq. in.
Minimum " " " idling r.p.m. ...	15 lb/sq. in.
Specific fuel consumption, take-off 1.23 lb/lb/hr. ...	10,200 r.p.m.
" " " climbing 1.23 lb/lb/hr.	9,700 r.p.m.
" " " cruising 1.30 lb/lb/hr.	8,700 r.p.m.

Dimensions

Maximum diameter	50in.
Length (engine air intake to propelling nozzle) ...	107in.
Propelling nozzle diam. (internal)	16in.
Propelling nozzle length	6.25in.
Exhaust cone length (standard)	43in.
Impeller tip diam.	31in.

Weights

Rotating assembly	337 lb.
Combustion chambers (15)	289 lb.
Junction box	111.5 lb
Centre casing	66.8 lb
Support cylinders	31.0 lb.
Tail pipe	126.0 lb.
Diaphragm and insulating plates	19.0 lb.
Turbine bearing housing	19.5 lb.
Turbine shroud	22.5 lb.
Diffuser rear cover	103.0 lb.
Diffuser casing	277.5 lb.
Sundries	99.5 lb.
Engine accessories	68 lb.
Total weight	1,550 lb.

The starting cycle is completed when the r.p.m. have risen to 3,000, and the pilot takes over from this point. About three minutes of slow running at 5,000 r.p.m. is recommended before opening up to take-off conditions. All throttle movement should be made slowly, and the time taken to increase the engine speed from idling to maximum r.p.m. should be not less than ten seconds.

Before shutting down, the unit should be allowed to idle and cool off for about half a minute. The high-pressure fuel distribution valve should then be closed, and this action causes the drainage of the fuel system and the release of the safety catch holding open the starting valve diaphragm.

In emergency it is possible to stop the engine quickly by simply cutting off the fuel supply, but this results in the deluging of very hot components with quantities of cold air and the drop in temperature may cause damage.

If a Goblin has for some reason stopped in the air, restarting may be attempted at an engine speed of about 1,200 r.p.m., but this is an emergency operation.

The following engine instruments are provided in the cockpit in addition to the oil-pressure warning lights already mentioned: jet pipe temperature indicator (zero to 800 deg. C.); turbine bearing temperature indicator (zero to 200 deg. C.); a fuel-pressure gauge (zero to 800 lb./sq. in.); rev-counter (zero to 20,000 r.p.m.).

Goblins are at present installed only in the Vampire single-seater fighter which is in production for the R.A.F., but trial installations in other aircraft, in this country and America, have met with equal success, and shown it to be a reliable and excellent turbine-jet unit. In the Sea-Vampire, the Goblin became the first pure jet unit to make a deck landing and take-off.

TURBINES for AIRCRAFT

Four-stroke Piston Engines and Turbine/Jet Units Graphically Compared : Effect of Rotary Power on Aircraft

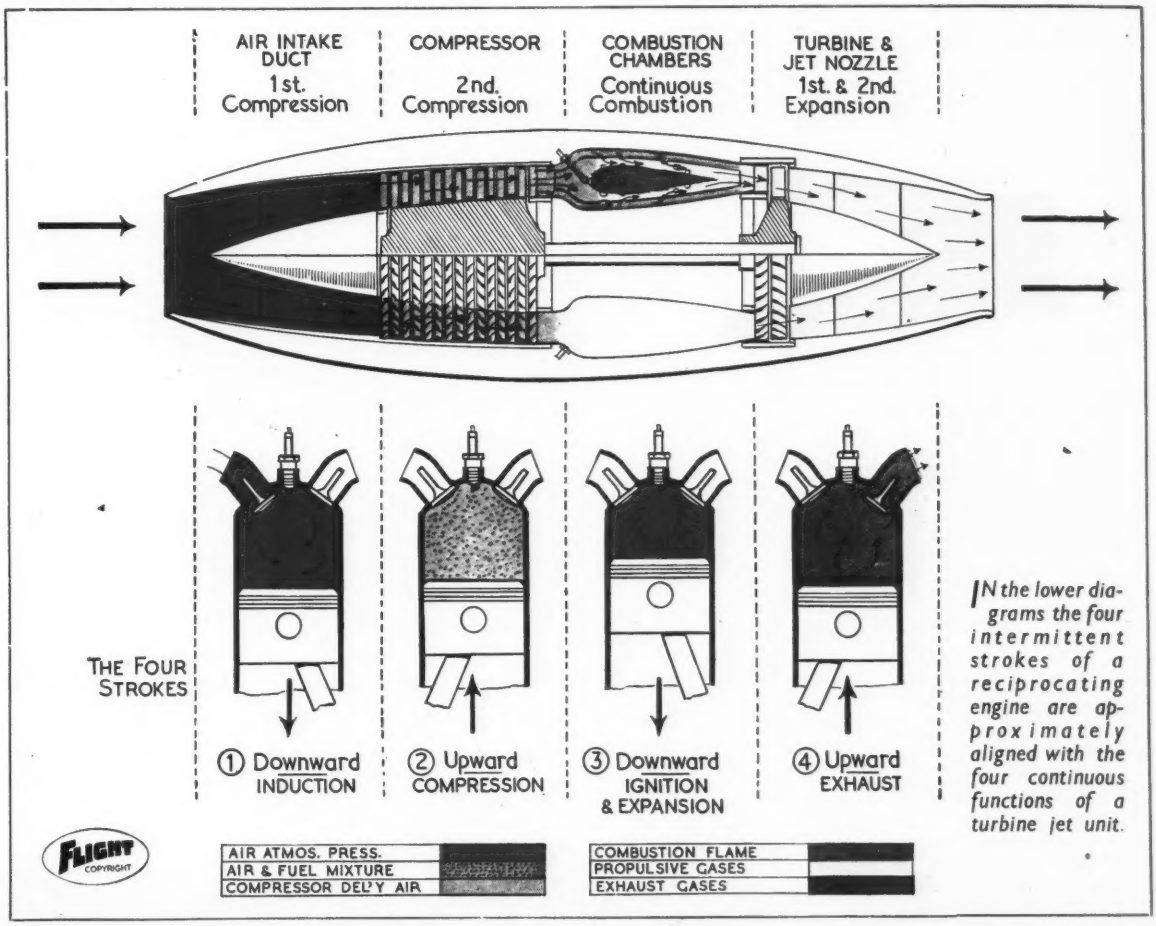
By G. Geoffrey Smith, M.B.E.

ALTHOUGH a great deal has been written about gas turbines and jet propulsion during the past two years, many people still have but a hazy idea of their functioning and characteristics. From 1941 onwards *Flight* exclusively devoted a long series of discursive articles to the important development of rotary power,* and drew attention to the immense potentialities of the gas turbine as the future power unit for aircraft. At that early stage it was only possible to discuss and illustrate the general principles and projected designs from many countries. Now that the features and construction of successful modern aircraft turbines may be revealed the accompanying diagrammatic drawings will assist in clarifying points about which some dubiety may exist. A knowledge of fundamentals is the more necessary in view of the present spate of lectures, some of them of an advanced character including thermodynamic data.

To obtain a thorough understanding it is desirable first to compare the action of a normal four-stroke engine in relation to a gas turbine-compressor unit for jet propulsion. Diagrams reproduced on this page are designed to facilitate such a study.

The lower series of drawings shows in simple form the complete cycle of the orthodox four-stroke piston engine: (1) INDUCTION, (2) COMPRESSION, (3) IGNITION and EXPANSION, (4) EXHAUST. All four functions take place in regular sequence in each cylinder of a multi-cylinder engine during every two

* *See also "GAS TURBINES & JET PROPULSION FOR AIRCRAFT" (Flight Publishing Co., Ltd.), of which three editions have already appeared in Great Britain and has also been published in U.S.A. and Europe.*

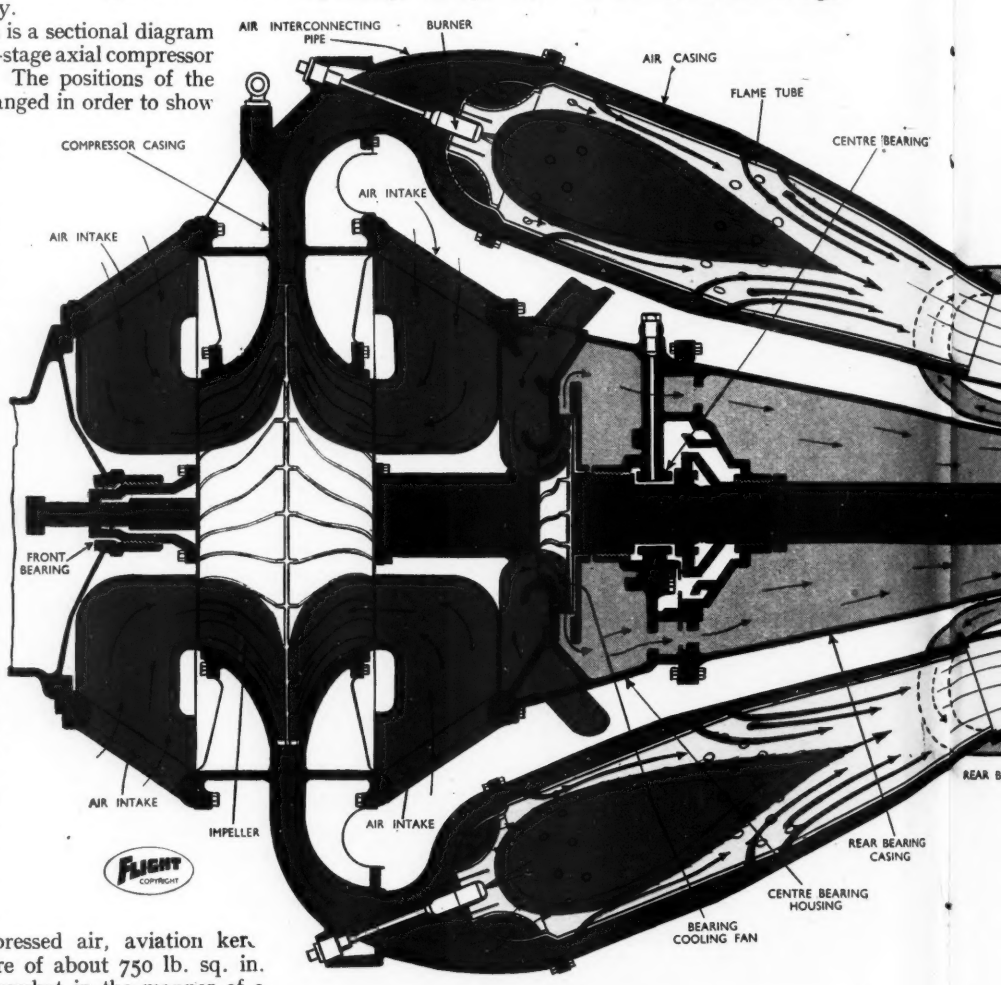


IN the lower diagrams the four intermittent strokes of a reciprocating engine are approximately aligned with the four continuous functions of a turbine jet unit.

TURBINES for A

revolutions of the crankshaft. Stroke No. 3 is the only power stroke, the expansion of the ignited fuel/air mixture, previously compressed to a ratio of about 7 to 1, forcing the piston downwards. In an engine operating at a crankshaft speed of 3,000 r.p.m., each stroke is completed in 1/100th second and a complete cycle of operations in 1/25th second. As the power stroke occurs only once in every two revolutions of the crankshaft the working energy is applied to the shaft intermittently, the frequency depending, of course, upon the number of cylinders. It will be understood that the greater the number of cylinders the nearer is the approach to continuous application of energy.

Above this set of diagrams is a sectional diagram of a gas turbine with a multi-stage axial compressor and a single-stage turbine. The positions of the two diagrams have been arranged in order to show their corresponding functions in relation. In comparing the action of the two types of engines it is important to appreciate that the turbine produces power continuously, that is, there are no intermittent explosions as in a two- or four-stroke reciprocating engine



How it Works

A turbine/jet engine consists of three essential components, (1) a rotary air compressor at the front, (2) a series of combustion chambers into which kerosene is sprayed and burnt continuously, and (3) a turbine revolving with the compressor on a common shaft. There are no pistons, valves or ignition apparatus save for two igniter plugs to attain a start. Initially an electric starter motor spins the main shaft at about one-eighth speed. Atmospheric air is induced at the front by the action of the rotating compressor, forced by the same compressor into the combustion chambers at a ratio of about 4 to 1 and into this compressed air, aviation kerosene is pumped at a pressure of about 750 lb. sq. in. and burnt continuously, somewhat in the manner of a plumber's blowlamp. Only a small quantity of air is used for combustion and the tremendous heat generated expands the main volume of air surrounding each of the flame tubes. As the chambers have an open end, in contrast to the closed cylinder of a piston engine, there is no rise in pressure, but by reason of the rapid expansion, the heated air and combustion products at increased velocity force their way through the only exit from the chambers, namely, between the blades on the periphery of the turbine wheel. The rapid expansion of the heated mixture through the airfoil shaped blades (about 50 of them) causes the wheel to rotate rapidly—from 8,000 to 16,000 r.p.m., for example, at full speed. In this manner mechanical energy is created at the shaft, and the compressor fixed to the front end of the shaft is made to do its work in compressing more air into the combustion chambers and the process goes on so long as fuel is introduced. All the power delivered by the turbine is expended in driving the air compressor and the necessary auxiliary equipment. To drive the compressor approximately 100 h.p. is required for each lb. of air delivered per second. A pound of air per second gives about 50 lb. thrust, therefore the turbine of a unit developing 2,000 lb. thrust must deliver about 4,000 h.p. From the rear of the turbine the heated air, still expanding, emerges from the tail nozzle as a high-velocity jet, say, 1,800 ft. per second, or 1,227 m.p.h. The temperature at the outlet is down to about 300 deg. C., compared with 690 deg. C. maximum as it enters the jet pipe. Actually, it is not strictly correct to term the efflux "propulsive gases." The propulsive effort is the reaction of the force expended in ejecting the gases. A familiar example of jet reaction is the garden rotary water sprinkler.

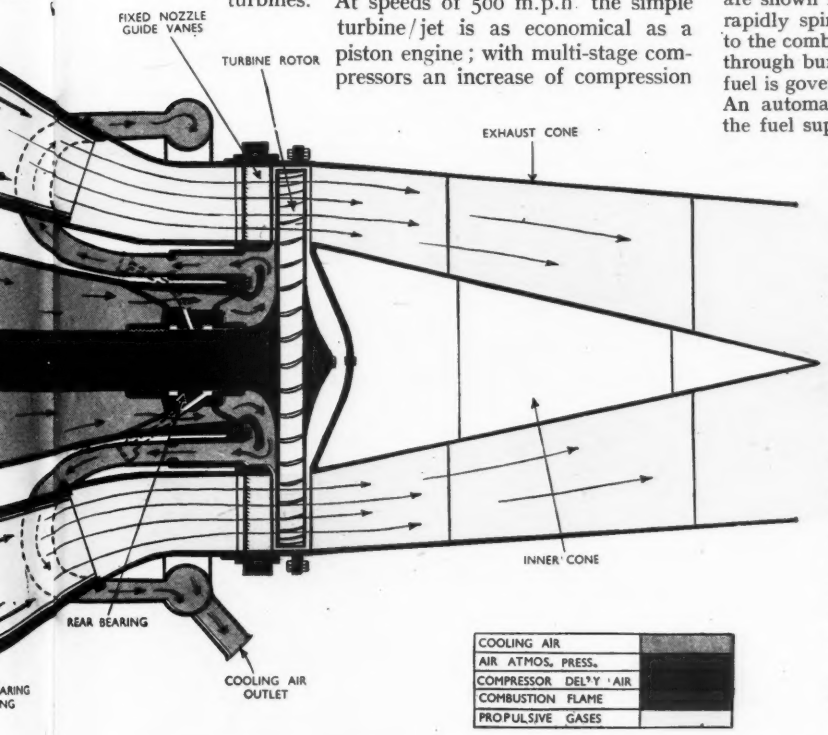
Because there are no fluctuating pressures as in a piston engine, the combustion chambers can be of a light welded sheet-steel construction.

Rotary action and continuous operation impart a smoothness of operation to a turbine never before achieved in aircraft power units. They virtually have no out of balance forces. The relatively small bulk, smooth exterior and light weight give the turbine an immense advantage over a piston engine. It requires no cooling radiators and because there are no metallic

r AIRCRAFT . . .

rubbing surfaces and only two or three shaft bearings, lubrication is greatly simplified. It is possible to start a turbine from cold and take off in less than a minute at full throttle and the engine kept at maximum rating. The only critical factor is the temperature of the gas flow at the turbine, indicated by a thermometer on the instrument board.

The overall thermal efficiency, that is the heat value of the power delivered as thrust, expressed as a percentage of the heat value of the fuel consumed, is often adversely criticised by those who quote figures on a pints-per-hour basis. If considered in relation to distance traversed and weight carried in a given time, such a ton-miles comparison is favourable to gas turbines. At speeds of 500 m.p.h. the simple turbine/jet is as economical as a piston engine; with multi-stage compressors an increase of compression ratio is possible with enhanced economy. Heat exchangers also offer great possibilities in this connection.



GAS TURBINE/JET UNIT IN OPERATION.

A DOUBLE-SIDED centrifugal compressor delivers air to the combustion chambers into which kerosene is injected and burnt continuously. The heated air and combustion products force their way through the blades of the turbine rotor, so creating mechanical power necessary to drive the compressor.

At high altitudes in regions of low temperature, gas turbines operate more efficiently. Component efficiencies, too, are improved by the ram effect of air entering at high forward speed. Again comparing the two engine types, the constantly varying processes of induction, compression, expansion and exhaust take place in one organ, the cylinder, whereas a turbine does not have this handicap as the processes are carried out in separate specialised components which can be individually studied.

DERWENT FEATURES

Having grasped the main differences in the cycle of operations of a four-stroke and a turbine engine, the reader should now study the sectioned diagram of the Rolls-Royce Derwent I turbine/jet unit which has been coloured to illustrate the functions. This design is based upon the designs of Air Comdre. Frank Whittle, R.A.F., and Power Jets, Ltd., with the important change from reverse flow to "straight through" combustion chambers evolved by the Rover Co. at their Barnoldswick factory and developed in association with M.A.P. and Joseph Lucas, Ltd.* Rolls-Royce took over turbine development work from the Rover Co. in April, 1943, to supplement their own active research instituted in 1938.

The turbine/jet unit illustrated incorporates at the front a centrifugal compressor having an impeller about 21in. diameter with twenty-nine radial blades on each side. At the other end of the shaft is a single-stage axial flow turbine. The main shaft is carried in three bearings. Two of the ten combustion chambers grouped around the shaft are shown in section. Air is induced on both sides of the rapidly spinning impeller and fed past the diffuser necks to the combustion chambers into which kerosene is pumped through burners as a finely atomised spray. The supply of fuel is governed by a throttle valve controlled by the pilot. An automatic barometric control is also fitted to reduce the fuel supply to the burners at altitude. When starting up, the fuel is ignited by two ignition plugs, thereafter the burning mixture maintains continuous combustion.

Combustion Chamber Design

Each combustion chamber consists of an outer casing in which is arranged a co-axial flame tube furnished with two series of holes to admit primary combustion air and dilution air respectively from the annular space between the two elements to the interior of the flame tube. The air casing is capped by a connecting pipe flanged to both the casing and the diffuser neck of the compressor. At its opposite end, to permit thermal expansion, the casing makes a sliding joint with the discharge nozzle leading to the turbine guide vanes. The flame tube is located from the casing by three radial supports in the region of the primary combustion zone, and at its rear end is guided with freedom to expand in the end of the casing. Two of the three radial supports are in the form of tubular stubs to receive the short pipes by which the casings of all ten chambers are interconnected.

Socketed on the forward end of the flame tube is a perforated domed cap known as the "colander." Probably coined in the workshop, this designation has now passed into official use. In the centre of the colander is a sleeve to receive the fuel burner and around the sleeve a ring of vanes to promote a helical swirling of air around the fuel spray. A perforated inner cone extends from the swirl vanes to the junction of the flame tube. The function of the swirl vanes is to ensure a continuous flow of air with an organised turbulence to the atomised fuel whilst the colander, lowering the velocity and damping out any pulsation, provides locally stabilised ambient conditions and avoids any possibility of the flame being "blown out." The work of compression raises the air temperature from, say 15 deg. C. to 205 deg. C., and through the first series of holes in the flame tube the air feeds into the interior to maintain an air-fuel ratio of approximately 18 to 1. The second series of holes admits the so-called dilution air which increases the fuel-air ratio to about 60 to 1 and reduces the temperature from 1,800 deg. C. in the combustion zone to 850 deg. C. for delivery to the turbine. Heat is expended in the passage through the turbine and the jet temperature is approximately 690 deg. C.

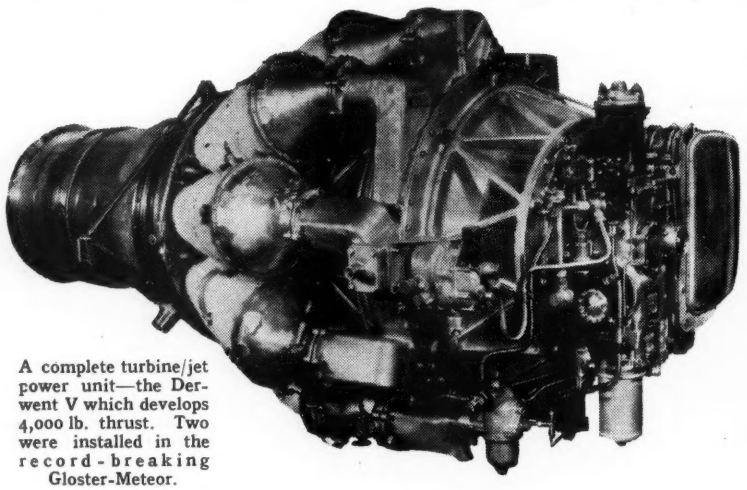
Connecting the combustion chambers is a series of balance pipes to equalise the pressure and allow the flames

* See *Flight*, January 3rd or 10th, 1946.

TURBINES for AIRCRAFT

to ignite the fuel in adjoining flame tubes when starting up. Combustion is completed (as shown in red) before the expanding gas enters the fixed turbine vane ring or nozzles which direct the rapidly issuing gas stream at an appropriate angle on to the blades of the turbine rotor. The efflux continues through the tail nozzle for final expansion. Incidentally, the de Havilland Goblin turbine/jet in the Vampire is much on the same general lines, but in this case a single-sided centrifugal compressor of larger diameter is utilised and sixteen combustion chambers also of "straight through" type.

Combustion of fuel at such a high rate generates tremendous heat. In the Derwent, means are provided to cool the internal mechanism, including the centre and rear bearings and the front face of the turbine disc. A small centrifugal fan mounted in front of the centre bearing induces atmospheric air through short stub pipes on the front end of the engine housing and forces it through the cooling air manifold to the exhaust outlet at the rear, as indicated in light green. When it is realised that the turbine rotor runs in a gas temperature of about 850 deg. C., and that the 54 individual blades, measuring about 3in. long and 1.25in. wide, have to transmit about 75 h.p., the importance of the metallurgical problems and the need for internal cooling will be understood. Apart from the anti-corrosive nature of the nickel chromium alloys used, non-creep properties are of the highest importance. A high tensile strength must be maintained even under high working temperatures, as centrifugal force due to high speed of rotation imposes a heavy mechanical stress. Because of this high speed of rotation the compressor impeller and turbine rotor each need to be statically and dynamically balanced, both individually and collectively as a single assembly. This explains the fact that the two shafts carrying compressor and turbine are connected by a quick detachable toothed coupling. The impeller which has the larger diameter has a tip velocity of approximately 1,500 ft./sec.—that is considerably in excess of sonic speed (1,100 ft./sec. at sea level and less at altitude).



A complete turbine/jet power unit—the Derwent V which develops 4,000 lb. thrust. Two were installed in the record-breaking Gloster-Meteor.

The installed weight of the Derwent V engine is under 1,500 lb. and it delivers 4,000 lb. thrust—a power/weight ratio never previously attained. For the world's record, two of these units on the Meteor developed sufficient power to attain 606 m.p.h. when throttled down to 3,600 lb./thrust. Fuel consumption on the record was high, as full throttle low altitude conditions are the least favourable to thermal efficiency.

Thrust and Horse Power

It is not possible to compare thrust power with horsepower save under a given set of conditions, but at 375 m.p.h. 1 lb. of thrust is equivalent to 1 h.p. The overall efficiency of a jet-propelled aircraft is dependent upon forward speed. Thrust is proportional to the rate of change of momentum of the working fluid, in this case air. But the comparison does not cease there. If air entered the nose at 300 m.p.h. and emerged at the same speed, the thrust would be zero. Propulsive efficiency is a function of the relative speed of the aircraft and the jet efflux. Inherently a jet-propelled aircraft scores by reason of the reduced drag occasioned by the smaller dimensions of a power unit devoid of excrescences, and the lighter overall weight of the aircraft. In this connection it has been estimated that the Gloster Meteor would have needed two piston engines developing a total of 12,000 b.h.p. and weighing probably 20,000 lb. in order to equal the record speed.

Benefits at Altitude

At sea level the drag of an aircraft is much higher than in regions of reduced density. For several reasons a jet aircraft is more efficient in operation and capable of longer ranges when flying at altitude. The benefit of lower ambient air temperatures to the efficiencies of both the compressor and turbine components has already been stressed. To this favourable combination of circumstances, when flying high a further contributing factor is the ram effect of entering air scooped into the intake by reason of the higher speed now attained. In the ultimate, efficiency of the power unit is governed by the mass of air flowing through the plant and the degree to which the air is accelerated rearwards.

Among the advantages of axial flow compressors (see diagram on page *a*) are a reduction in diameter and a higher ratio of compression. So far as German examples are concerned, they are much heavier and more complicated in construction than the simple British centrifugal compressors of equivalent performance. Propulsion units with axial compressors have not shown as favourable a rate of consumption up to the present. The future trend, however, may confidently be expected toward the axial flow unit, particularly for the extremely powerful engines now required to equip our projected long-range air liners.

Turbines will Revolutionise Air Travel

Up to last year the war necessitated concentration upon military types of turbines mostly of high performance and short range. Now the way is clear for a closer study of power units for civil aviation, and the view is reiterated that the advent of the turbine will exert profound influence upon aircraft design; indeed, nothing short of a revolution. Higher speeds and improved ton/mile figures will be achieved by employing the lighter and more powerful turbine unit. By the elimination of vibration, structural weight of the craft can be reduced, and in operation the smooth running and silence will be appreciated by passengers and crew. The rapidity of development of a new design of gas turbine—six months as compared with the normal four years for piston engines—is of immense advantage. In the factories, production is greatly facilitated as there are approximately only one-third the number of parts entailed in a turbine/jet engine.

It is not too optimistic a view that before the present year ends long- and short-range transocean air liners having air-conditioned cabins and propelled by gas turbines of 10,000 equivalent h.p. will be evolved. Later, gas turbines employing either tractor or pusher propellers may be confidently predicted. This is the age of rotary power, and in the pioneer development of gas turbines British engineers have established a leading role

CIVIL AVIATION

Air Transport and The Public

Lord Knollys' Brancker Memorial Lecture to the Institute of Transport : To Australia in Twenty-four Hours?

Viscount Knollys

"SAFETY, regularity, speed, comfort, cost, frequency, and with them all, service." These were the qualities which passengers looked for in an air service, said Viscount Knollys, the chairman of B.O.A.C., when he gave the Brancker Memorial Lecture before the Institute of Transport last week.

In what a later speaker described as a "well and clearly balanced statement," Viscount Knollys surveyed the present-day demand for air transport and the way in which it is to be met. He said that the foundation of all air transport was the desire to get from A to B, and that the development of air routes began with the study of how many and what kind of people want to fly from where to where, how often, and when. In calculating these figures, allowance had to be made for a percentage of those who travelled by ships before the war and who would now transfer to air travel (because it lessened time away from home, or increased time at destination or *en route*), and also for "induced" traffic—those who would not have travelled at all had air transport not been available. Finally, services had to be added to meet G.P.O. requirements and to deal with express and freight traffic.

As to the route, the shortest was not always the best. There were still good reasons why "traditional" transport routes should be followed so as to link up centres of population and trade, and to encourage intermediate traffic.

Lord Knollys said that there had been schools of thought which had said, "Here is a superb aircraft; it flies at 400 m.p.h., carries 100 passengers 3,000 miles non-stop. Now on what route can we fly it?"—whereas, in fact, it was for designers to produce the right kind of aircraft for a particular job after studying the operators' commercial needs.

Many aspects of air transport and many routes were entirely new. The North Atlantic route was a case in point. There was no reliable guide to its traffic potential because, before the war, it was only in the experimental stage. The kind of problem which had to be determined was whether it was best to concentrate on a high degree of comfort, as in sleeper aircraft, or whether to provide seating accommodation only. The old limitation of flying short stages and spending each night on the ground no longer applied. We were able to complete stages of up to 2,000 miles, or even more, by day or by night.

> . . . . . *study of how many and what kind of people want to fly from where to where, how often, and when.*
>
> . . . . . *the shortest not always the best route.*
>
> . . . . . *we are now able to complete stages of up to 2,000 miles, or even more, by day or by night.*

There were those who wanted to fly very fast right through from England to Australia. This class of traveller had been met by the 63-hour Lancastrian service between U.K. and Sydney. There were others who wanted a more leisurely journey, for business or sight-seeing purposes—but it was not necessary to supply special services for them. It was really for the traffic department to make sure that those passengers who had stopped *en route* caught the next convenient onward service. From the operators' point of view, it was more economical for the aircraft to fly on, for an aircraft earned money only when it was in the air.

There was also a third class of traveller who wished to see the world by air, but who was unable to pay *de luxe* fares and was therefore prepared for less comfort. These were the travellers we wanted, and whom we ought to encourage to fly, and it was B.O.A.C.'s definite aim to provide this cheaper travel. Really cheap air fares, justified on cost, were not yet feasible, but with the right type of aircraft, and the increase in traffic which cheap fares in themselves would bring, a downward trend should not be too long delayed.

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>
> . . . . . *really cheap air fares, justified on cost, are not yet feasible.*
>
> . . . . . *B.O.A.C. has well over forty captains who have each flown more than 1,000,000 miles.*

The qualities which passengers looked for in an air service were all closely bound together. Safety, regularity, speed, cost, comfort and service were obviously related.

Safety and Confidence

Lord Knollys reviewed each of these factors in turn, and pointed out that safety was the first requisite of any form of transport, although he preferred the word "confidence"—the confidence of the public in the transport operator. The authorities must provide the very best facilities on the ground, and the operators must provide the highest standards of training, equipment, inspection and discipline. Standards of training would be higher than ever, as befitted a service which had to operate over the winter Atlantic and through the tropics, meeting entirely different sets of weather conditions. Lord Knollys said that B.O.A.C. had well over forty captains who had each flown more than 1,000,000 miles, or about 8,000 hours, and it was hoped that, before long, B.O.A.C. would establish its own training school.

With training was associated the equally important matter of maintenance. The keyword of good maintenance engineering was "prevention," and this, too, affected safety and regularity. Maintenance, if an airline was to be made to pay its way, had to be scheduled to be fitted in during brief intervals in a busy timetable. One necessity was the perfect interchangeability of components.

On the the subject of regularity, Lord Knollys rightly said that, from the passengers' viewpoint, the most irritating thing in long-distance travel was any failure to leave at the time, or even on the day expected. However, in order to provide regularity, high speed and extended range were necessary, and these could not be obtained without penalties in higher costs or the sacrifice of payload.

CIVIL AVIATION

Speed was the supreme asset of air transport, and although British air services were already providing rapid travel to such places as Australia, India and Egypt, we were, nevertheless, on the threshold of dramatic increases in speed. The prospect of speeds which would bring Australia within 24 hours of London, New York within 6 hours, and Johannesburg within 14 hours were within known possibility, even if that possibility was still distant. These speeds brought new problems, such as those concerned in pressurisation for flying at great heights. They also involved problems of space and time in relation to human needs. He instanced the complexity of the meal arrangements made for passengers leaving London at lunch time and arriving in New York at lunch time the same day!

Comfort in the air was a question of relativity. There were many things that airline operators would like to give passengers, but they all affected performance and cost. There was a tendency to confuse comfort with luxury. Lord Knollys agreed, however, that the longer the continuous air journey, the greater the comfort needed. It was no good transporting people by air from England to Australia in three days if a further 24 hours was to elapse after arrival before they were fit to undertake business or to enjoy themselves. To make passengers comfortable on voyages of several thousands of miles, with perhaps three sets of climatic conditions ranging from very cold to highly tropical, was an involved task.

Air Travel for All

So far as cost was concerned, Lord Knollys subscribed wholeheartedly to the doctrine that air travel must *not* be only for the well-to-do. The greater the volume of travel by air, the cheaper it would become—thus generating more travel. He made the excellent point that the people in this country were not air-conscious in the same sense as Americans were. They were only "R.A.F.-conscious." Though British airlines were owned and capitalised by the State, they still had to be run primarily as sound commercial concerns.

The public would be given what they needed in the way of frequency of services, and he considered that a daily frequency was the minimum on routes with any real traffic. A half-hour service through most of the day, on a route such as that between London and Paris, was not too much. Passengers did not always want to book; they wanted to arrive at an airport and catch the next service.

The final public demand was for service, and the more individual was the service the better. Where the public found that it got good service, that line was used again. A smooth and efficient service had to be planned; it did not just happen.

But Lord Knollys added: "You cannot sell seats in the air on service alone; nor alone with the best aircraft, nor with the most complete ground organisation. All three are needed to make up the first-class airline. And this country is going to have all three."

Among the speakers who took part in the debate which followed, Air Vice-Marshal Sir Hazelton Nicholl, formerly R.A.F. Establishments Officer to B.O.A.C., stressed the point that confidence in air travel would increase with aircraft punctuality, and that the more points of call there were on routes, the better it was for "showing the flag." Mr. R. Kelso, chairman of the General Steam Navigation Co., as might have been expected, made a point of the need for good service to the individual on air lines, and for comfortable travel to and from airfields. Sir William Wood, president of the L.M.S. Railway, raised the interesting question whether, in aircraft, bunks were better placed longitudinally than transversely in order to minimise the possibility of air sickness. To this, Lord Knollys replied that a balanced load was the real problem—one with which the railways did not have to contend. He added that on very large aircraft there would be transverse bunks.

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>
> . . . . . *people in this country are not air-conscious . . . only R.A.F.-conscious.*
>
> . . . . . *on the very large aircraft there will be transverse sleeping bunks.*

There was some sharp criticism of certain aspects of B.O.A.C.'s detailed service from Mr. K. E. Shelley, K.C., and Mr. Vivian Davies. They asked, particularly, that passengers should not be "kept in the dark" about delays and aircraft snags. On the other hand, Major R. H. Mayo, who is technical adviser to B.O.A.C., considered that the Corporation had achieved a great deal in the most difficult circumstances. He pleaded for "tailor-made" aircraft for individual routes, and recommended that operators should specify the designs for their own aircraft and not leave them to such bodies as the Brabazon Committee. Brigadier-General Sir Osborne Mance asked for international agreement on competition between airlines so as to avoid subsidies. Lord Knollys agreed that subsidies were undesirable, but pointed out that there were some vital routes which, although they did not pay, would always have to be maintained.

Sir Frederick Handley Page, president of the Institute, who was in the chair, said that he hoped attention was being directed towards the designing of aircraft to fly at 500 m.p.h. at 50,000ft., and remarked that faster aircraft meant shorter journeys, thus making possible the acceptance of greater austerity in passenger comfort, with consequent reduction in costs. He also considered that to use one type of aircraft for routes of varying length was not to make the most economical use of the machine. He also commented on the need for noise suppression in aircraft, but Lord Knollys neatly passed this one back to Sir Frederick on the score that it was the manufacturers' concern to ensure this in the first instance.

Unloading the Liberator at Prestwick airport on the completion of B.O.A.C.'s 2000th crossing of the North Atlantic. This flight took 13 hr. 38 min. for the 3,104 miles from Dorval in Canada.

Bermuda Agreement

International Control of Airline Rates : Basis for Acceptance of "Fifth Freedom" Principles

THE Bermuda talks have ended satisfactorily. On February 11, the British and United States delegates signed three documents which they regard as the foundation of International Civil Aviation. The first document deals with fares, frequency of services, scheduled routes and traffic rights generally.

The second document forms a basis for agreement to the civil use of military air bases leased by Britain to America.

The third, and final act of the Conference outlines machinery for close collaboration, and for the settlement of disputes between the two Governments. It indicates that the principles agreed upon aim deliberately at encouraging the use of air transport, and stimulating air travel at economic rates. At the same time, these principles allow fair and equal opportunity for the various airlines of the two nations to operate between the U.K. and the U.S.A., and also to provide air transport facilities equal to the public demand. It also contains a basis of agreement on "fifth freedom" traffic. This was one of the bones of contention at the Chicago Conference in 1944, and it is clear that there has been a modification of the British attitude to this controversial question, for the right to pick up and set down passengers anywhere on international routes has now been recognised with certain provisos.

This "fair and equal opportunity" does not imply that the two countries have agreed upon a definite allocation of service frequencies. Rather, it gives each nation the right to offer whatever services it believes to be justified under the principles already agreed. Special consideration will be given to safeguarding the rightful interests of both countries, and to bridging any period during which difficulties resulting from the war might react to the prejudice of either country.

Fares and Fifth Freedom Traffic

The terms of the agreement are broadly as follows:

In order to ensure economic operation, and to prevent "rate wars" resulting from unfair and uneconomic rates, the two countries have agreed on the regulation of fares. All rates charged by airlines operating between the two countries will be subject to review by the aeronautical authorities of both Governments. Proposals for new rates are to be notified to both Governments 30 days before their effective dates, and, if jointly agreed, the new rates can be adopted. If at the end of the 30-day period the two Governments cannot agree on the rates proposed, they may, nevertheless, be put into force at the discretion of the Government concerned pending a final settlement. If a final settlement cannot be reached, the matter will be referred to the P.I.C.A.O. for a report by its advisory committee. The United States is to recognise, for a period of one year, the status of the International Air Transport Association as a rate-fixing body, acting through the I.A.T.A.'s various route conferences. An undertaking has also been given that legislation will be sought from Congress to empower the Civil Aeronautics Board to control rates for U.S. airlines on international routes.

Each country will have complete freedom to determine the frequency of operation of its own airlines.

The right to pick up and set down passengers anywhere on international routes in accordance with defined principles has been recognised. It is subject, however, to adjustment as necessary in particular cases in the light of experience. The privilege continues so long as this form of traffic does not defeat the primary objective of agreed international air services, which is to provide adequate air transport for the traffic between the home country and the country of destination. In order to regulate "fifth freedom" traffic, the general principles have been adopted that capacity should be directly related to:

(a) Traffic requirements between country of origin and country of destination.
(b) Requirements of through-airline operation.
(c) Traffic requirements of the area through which the airlines pass after taking into account local and regional services.

Common Air Routes

An initial schedule of world-wide air routes of mutual interest to the U.K. and U.S.A. has been agreed. This does not, however, touch Dominion or Indian territory. The proposed air routes include some already in operation.

Changes of route by one nation in the other's territory will be made only after consultation and agreement between the two aeronautical authorities concerned. Route changes in "third" countries may be made any time, provided that prompt notice is given. The conference has recognised that, from key points on the routes, it may be more economical to handle onward carriage of traffic in smaller aircraft than those used on the route itself. Such "feeder" services will operate only in relation to the larger aircraft arriving at the junction point so as to provide a connecting service, and the smaller aircraft will, therefore, normally await the arrival of the trunk route aircraft.

Air bases leased by the United Kingdom to the U.S.A. for military purposes under the Bases Agreement of 1941 will be opened for civil use whenever such use contributes to the overall development of civil aviation on sound economic lines. This means, in effect, that the leased bases in Bermuda, Antigua, St. Lucia and British Guiana will be available for civil use, and that other bases will become available as bad-weather alternatives to existing airports. America's approval to this is subject to the working-out of a satisfactory agreement covering similar arrangements for airfields in Labrador and Newfoundland. Complicated legal problems still have to be sorted out, but these will form the subject of further discussions.

Traffic Rights

The terms of the agreement safeguard the position of the traffic rights of the two countries on these bases. The United States will maintain the airfields for military purposes and she will have "most favoured nation" treatment in regard to the traffic rights. No other civil airline, including U.K. airlines, will be granted traffic rights greater than, or different from, those granted to America, except for certain instances of U.K. traffic between two points under U.K. jurisdiction.

Other provisions of the agreement cover the right of either Government to suspend, for military reasons, commercial operations at a base airfield, and the right of the U.S. military authorities to ensure that no steps are taken in connection with commercial air operations which would prejudice the military use of the bases. Further, if the U.S. wish at any time to relinquish responsibility for maintaining base airfields, the British or the Colonial Governments concerned would have the right to take over that responsibility.

There is provision for regular and frequent consultation between the two Governments to ensure close collaboration on all the principles agreed, and to provide a solution to new problems. Any dispute between the two nations relating to interpretation of the agreement, which cannot be settled by consultation, is to be referred to the P.I.C.A.O., or its successor, for an advisory report. It is emphasised that such a report would indeed be advisory and not mandatory.

CIVIL AVIATION NEWS

A VOICE IN THE WILDERNESS

THAT it was still necessary to educate people in air-consciousness was one of the points made by Mr. F. G. Miles when introducing the new Gemini on February 11th. He felt that it was necessary to destroy the atmosphere of adventure and danger which the war had reintroduced into flying. The private pilot was, he thought, still the backbone of flying and every possible encouragement should be given to this section of the flying community.

More Government consideration, in the way of labour and of money for research, was needed for all kinds of civil aircraft development.

CONTRETEMPS

IT is reported that France has refused to allow Pan American Airways to start a Marseilles to New York service, on the score that the U.S. rates are too low. The route should have opened several days ago, but official discussions ceased abruptly when the French learned that the proposed American fare was 295 dollars for the single journey. The fare agreed between America and ourselves for the New York-London journey is 375 dollars.

M. Georges Bidault, French Foreign Minister, is now negotiating with the U.S. Embassy, but, in the meantime, Pan American Airways' routine preparations for the opening of the line are continuing.

WHERE THEY CAME IN!

IN Australia, the Minister for Air has announced the lifting of all priorities for inter-state air travel. However, the lifting appears to be a gesture rather than a fact, for the operating companies have agreed to reserve seats for the President of the Senate, the Speaker of the House, members of the Cabinet, heads and senior officers of consulates and legations, judges of the High Court and associates, members of the Commonwealth Parliament travelling to and from sittings, private secretaries to ministers, and heads and senior officers of Commonwealth departments.

Formerly, Government passengers have regularly occupied two-thirds of the seating accommodation. It appears unlikely that there will be any very great change.

DOUBLE BREAKAGE

THE Lockheed Constellation which is said to have broken existing records for commercial flights between Cairo and Nchanga (N. Rhodesia), and between Johannesburg and Cape Town, struck a tree and a rock on the perimeter of the airfield when it completed its flight from New York at Cape Town on February 11th. The resulting damage to the aircraft may delay it for several days.

The aircraft stopped at Shannon, Rome, Athens and Cairo, and its flying time for the complete flight from New York to Johannesburg (9,792 miles) was 39 hr. 28 min.

It is noteworthy that this Constellation was held up at Nchanga by bad weather, whilst the B.O.A.C. "luxury" York, which was on a proving flight from U.K. to the Cape, arrived on its scheduled time of 39 hr. 15 min. for the complete journey. As the York was due at Johannesburg at the same time as the Constellation, it presumably flew through the bad weather which stopped the latter.

AMERICA ADVANCES

AN application has been filed with the Civil Aeronautics Board by Transcontinental Western Airlines, to start a new commercial route down the East African coast. Four-engined aircraft are proposed for the new service, which would add a 4,492-miles extension from Cairo to Johannesburg to existing T.W.A. routes.

The proposed new route would provide stops at Jeddah, Asmara, Addis Ababa, Mombasa, Dar-es-Salaam, Mozambique, and Lourenco Marques. The claim is made that such a route does not coincide with any existing B.O.A.C. or South African Airways schedules.

Yet another proposal of similar kind is announced from Turkey, where the American Ambassador is said to have signed an agreement for American aircraft on the United States-India route to fly over Turkey, making stops at Ankara and Istanbul. The service is expected to open next month, but it is not intended, apparently, that aircraft on this international route shall carry locally-embarked passengers between the two Turkish cities.

Meantime, at Algiers, the Maison Blanche airfield, which has been under the control of the U.S.A.T.C. for a very long time, was to have been handed back to the French about a week ago, but, at the last moment, it was reported that the handing-over ceremony had been cancelled on instructions from Washington.

BOAT PILOTS WANTED

PROBABLY the most serious shortage in civil aviation from the aircrew personnel point of view is that of experienced flying-boat pilots. For this reason B.O.A.C. has asked its Australian representative to select some fifty ex-R.A.A.F. pilots who have had at least a thousand hours' experience as pilots, five hundred of which have been spent in Sunderland or other flying boats. One gathers from this that there must be, surprisingly enough, a greater proportion of available experience amongst ex-R.A.A.F. personnel than there is in this country.

NORTH ATLANTIC CONFERENCE

THE United States is expected to send the largest delegation to the North Atlantic Air Route Safety Conference, which is to be opened in Dublin on March 4th. Twenty-six delegates have been named by the U.S. Government; Canada will have eleven representatives. It seems as if the conference may be a little unwieldy.

All countries operating—or likely to operate—on the North Atlantic route have accepted invitations to the conference, convened at the request of P.I.C.A.O., and the delegations will include representatives of operating companies as well as Government officials. The work will be handled by six committees after the plenary session in the State Apartments of Dublin Castle on the opening date. The conference is one of a series of international meetings to standardise flying practices and navigational procedure.

PILOTS FOR AER LINGUS

TEN pilots have recently been added to the staff of Aer Lingus (Irish Air Lines) and twelve more are to be recruited. The majority of the members of the expanded staff will be either Irishmen who served in the R.A.F., or former pilots of the Irish Army Air Corps.

The expanded staff is needed to deal with the shuttle service to be established between the Shannon Airport and London, and the direct service from Dublin (or Shannon) to Paris, which is to be opened soon. Conversion courses are being conducted by T.W.A. pilots who are on loan to the Irish company.

Nine Dakotas have been purchased from the U.S. Foreign Liquidation Commission at a price reported to be in the neighbourhood of £52,000. Other aircraft owned by the company include a Douglas D.C.3, two D.H.86s and a Lockheed Hudson. The latter is to be converted for freight-carrying, and another D.C.3 is to be delivered shortly.

MARK LACAYO

THE news of Flt. Lt. M. A. Lacayo's death in a flying accident last week will come as a bitter shock to many hundreds of pre-war amateur pilots and Service friends who knew and liked him so well. He was one of the founder-instructors of the Lancashire Aero Club in the very early days, and soon made flying his profession, putting in several thousand hours as an instructor and demonstration pilot.

After a period in the Army in France during 1939-40—as a result of his service in the last war he had been automatically commissioned in his old regiment—he eventually succeeded in arranging a transfer to the Royal Air Force. Well beyond the age-limit for operational flying, he was first posted to a ferry pool and then to No. 48 M.U., Hawarden, for test pilot duties. He was Senior Test Pilot at Hawarden and later at Lichfield, and was awarded the Air Force Cross for his consistently energetic work.

For more than eighteen months I was lucky enough to be his assistant at Hawarden in the days when that M.U. was turning out long-range Hurricanes as quickly as possible for the North African campaign, as well as Wellingtons, Liberators and a dozen other assorted types. At that time the unit as a whole was putting in a prodigious number of duty hours.

Although Mark could have given the oldest of his pilots ten years, he was always first in the air and last down again. His energy in, and enthusiasm for, test flying played as vital a part in the war-winning effort as that of any operational pilot. As a man he was kindness itself, and as a flight commander he never expected his pilots to do anything that he was not ready to do himself.

H. A. T.

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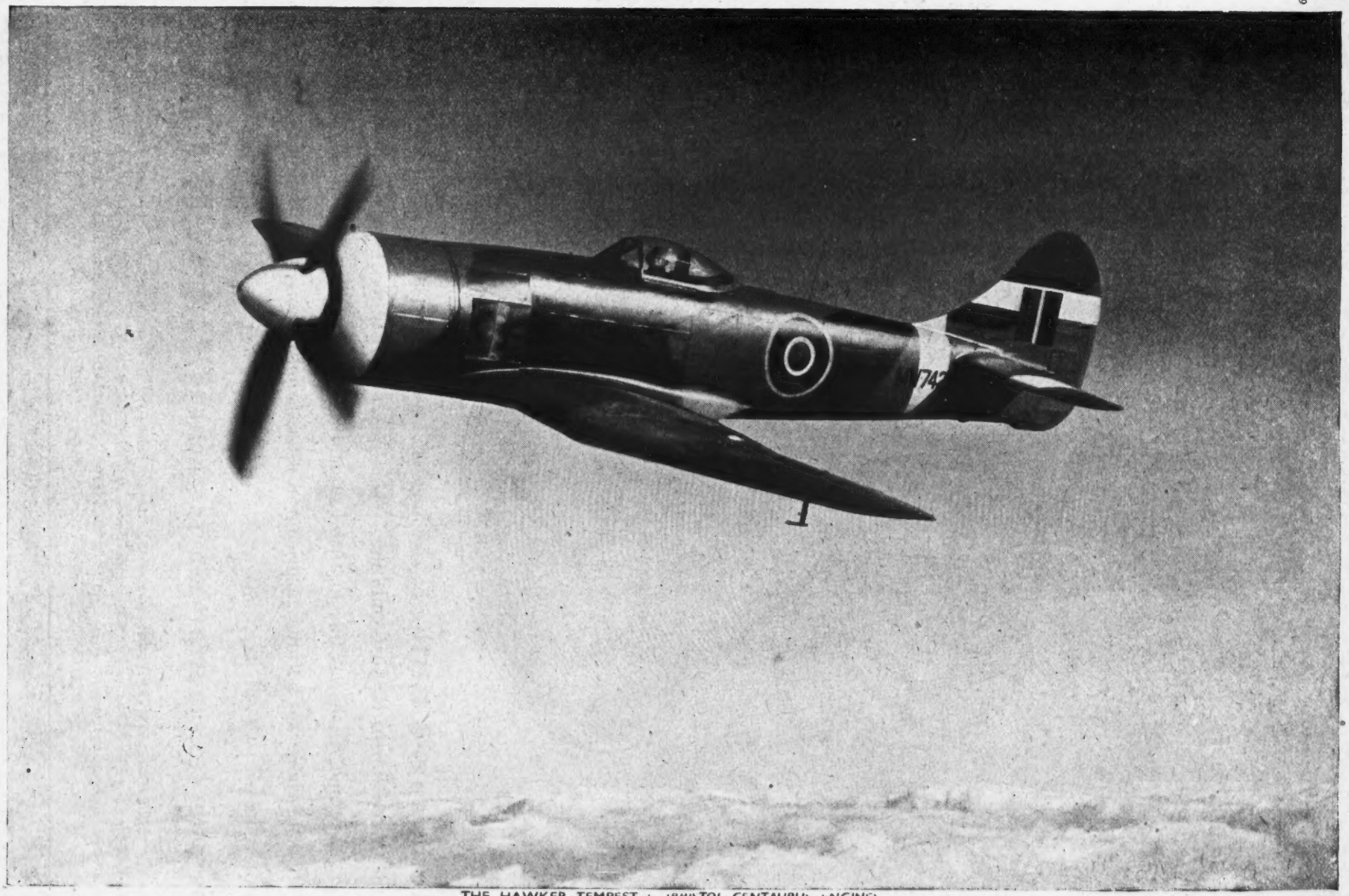

THE HAWKER TEMPEST II (BRISTOL CENTAURUS ENGINE).

We annoyed Hitler... as long ago as 1938 we sent a 22-inch Cathode Ray Bulb to the Berlin Radio Exhibition. This was, at the time, the largest television tube ever made and A. H. was furious that German glass-makers had allowed us to beat them to it. But there was nothing surprising in it—it is only among Englishmen that you hear how backward we all are.

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Control Boosters

Design Problems and Their Solution on the Lockheed Constellation

By CLARENCE L. JOHNSON

ONE of the most difficult problems encountered in the Constellation was the development of the control-surface hydraulic boosters. It has been necessary to overcome a considerable amount of opposition to the booster because of the usual objections to having mechanical devices in the basic control system which are more complicated and, probably, more subject to failure, than the well-proved cable-and-pulley controls. To overcome these objections it has been necessary to provide independent stand-by units to give control if the basic element should fail.

The operating principles of control boosters are not new. Steamships have used them for years; various large trucks are so equipped for steering, and a large percentage of motor cars and trucks use vacuum or hydraulic boosters for clutch and brake operation. The application to aircraft, however, is much more involved than those in the foregoing examples because of the close balance that must be obtained between control feel, stability and flutter factors, on the one hand, and reliability, weight and simplicity on the other.

THIS article is an abstract from a paper presented to the Los Angeles section of the American Institute of the Aeronautical Sciences by Clarence L. Johnson, chief research engineer of Lockheed Aircraft Corporation. Although the paper dealt with the full development of the Lockheed Constellation, only that section which referred to control surface booster development is reproduced here.

The Lockheed aileron servo unit was described and illustrated in our issue of April 5th, 1945. A British electrical control-assister, the Swift Synchromo, available in irreversible and "feel" forms, was referred to in our description (December 6th, 1945) of the Short Shetland flying boat, to which it was fitted.

Lockheed undertook the development of hydraulic control-surface boosters as a long-range research problem in 1939 before designing the Constellation. The decision to use the device on this aircraft was made at the inception of the design so that full advantage could be taken of all the benefits to be obtained without compromise. Five years of intensive development have solved, with the most gratifying results, the many problems brought up in applying the booster to a large aircraft. Future possibilities are appealing.

The decision to use a control-surface booster in the Constellation was made only after a complete study of all the factors involved. The advantages that would be obtained if such a device could be successfully developed were these:

(1) For a given control surface area, maximum control could be obtained, surpassing that obtainable with any known type of aerodynamic balance.

(2) For a given maximum controllability the surface equipped with a power booster has from 12 to 30 per cent. less minimum drag at cruising and high speeds.

(3) Control forces of any given value could be obtained without the danger of overbalance.

(4) The control surface equipped with the booster is in no way subject to overbalance in bad icing conditions, and there are no fabric seals to trap water and freeze.

(5) The basic control surface shape, when no aerodynamic balance is used and a booster is substituted, is much better adapted to high-speed flight where compressibility effects are a factor. Balance types II and IV (Fig. 3) are definitely known to be bad for high velocities.

(6) The power booster is the only device that can oppose unfavourable aerodynamic and flutter forces as well as create favourable ones. This feature will be extremely important for ultra high-speed aircraft operating near and in compressibility conditions.

(7) The value of the control forces could be readily changed, overnight if desired, or even made adjustable in flight within safe limits.

(8) The use of a power booster opens the way towards using an acceleration limiter on large aircraft designed to low margins of safety.

(9) For a given maximum controllability, the control surface equipped with the booster will weigh less than those with the aerodynamic balance.

(10) A control surface equipped with a booster combination can be highly insensitive to manufacturing tolerances and service damage, which is definitely not true for any aerodynamic form giving a high degree of balance.

With all the above advantages in favour of the booster, the question arises as to why all aircraft have not been universally equipped with such controls. Both hydraulic and electrical boosters have been, and are being, used on aircraft other than the Constellation. In several cases they were discontinued as being unsatisfactory. The failure of these booster applications may in all cases be traced either to (i) general service difficulties due to insufficient development; (ii) applying the booster as an aid to some form of aerodynamic balancing, trying to get it to reduce the hinge moment of the surface only at high deflections; or (iii) improper basic design criteria for the booster.

If the booster is combined with a type of aerodynamic balance designed to do a major portion of the work, many of its advantages are lost. Also, while the basic principles of the booster are extremely simple, there are many highly technical problems that must be overcome to obtain a successful unit.

The disadvantages of the control-surface booster are these:

(1) Necessity to provide automatic stand-by or dual means of operation to account for failure of the basic element.

(2) Added complication for service and maintenance.

(3) Control cable and booster valve friction multiply by the boost ratio used the difficulty of the surface finding its free floating angle. This is a serious problem in trim and stability.

(4) Vulnerability in military aircraft.

It is interesting to note that all the above disadvantages are of a mechanical nature and are, therefore, capable of being overcome by good design.

Before comparing various types of aerodynamic balances, it is well to review the critical control problems on a large aircraft such as the Constel-

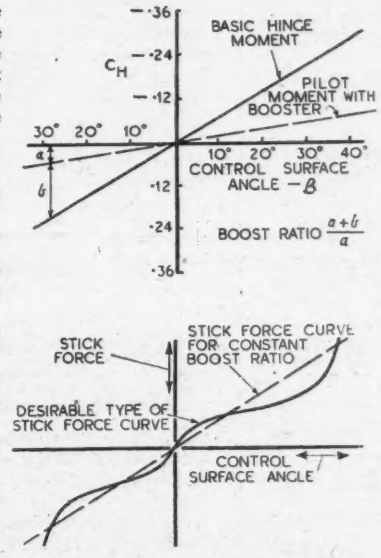


Fig. 1. Above: Definition of control boost ratio. Below: Desirable control hinge moment characteristics.

lation. (In an effort to improve manœuvrability with safety, a thorough study was made to find out what control forces a pilot wanted on a large aircraft. There were no actual values that could be used for design purposes when the booster was first designed, so the units were all made with variable boost ratios. After a considerable amount of flying by a number of pilots, the values shown in Table I were obtained.

The critical forces shown in Table I occurred respectively on landing at minimum two-engine-out control speed, and during approach in rough air. Elevator forces down to 35 lb. were tried on landing, but were found to be too light. The desirable forces have been obtained on the Constellation, except in the case of the ailerons, where a basic friction of 5 to 6 ft.lb. in the system makes it extremely difficult to obtain the desirable force.

Problems involved in obtaining these forces may be visualised when it is considered that the horizontal tail area for the Constellation is 10 sq. ft. more than the Electra 10A wing area, or almost half the wing area of the DC-3. To move one-fourth of this area through an arc of 40 deg. at an airspeed of 90 m.p.h. with a force of 80 lb. requires a substantial boost ratio or a close (and unobtainable) degree of aerodynamic balance.

During the flight tests to evaluate desirable forces, it became apparent that pilots want not only proper forces but also a shape of hinge-moment curve such as that shown in Fig. 1.

A substantially straight curve is given by the present type of booster, as indicated on the same figure. However, pilots want a steep slope of stick force against control surface angle through the neutral (or trim) angle to give ease of trimming, good static stability, and less tendency for over-control. At intermediate angles the force should increase slowly but positively. Near maximum angle the force should increase rapidly to prevent inadvertent stalling or over-controlling. It is possible to obtain this type of curve with a mechanical booster, giving an aircraft an apparent stability that may be impossible to obtain otherwise. This would be a great step in improving the flight characteristics of aircraft and a definite contribution to safety. Work is progressing in this field.

The Constellation was designed to have the maximum possible control about each axis. The ability to use small fields safely, meeting the Civil Air Regulations (Amendment 56), meant the possibility of carrying more payload in and out of more places, and put a premium on good control under the conditions outlined in Fig. 2. The incorporation of extremely high power in the aircraft led to the condition where the rudder and aileron control problem with one engine out was from 180 to 240 per cent. as great as that for other transport aircraft at a given airspeed. This came about by having powerful engines necessarily carried far from the fuselage because of the large airscrew diameter. The use of an extremely high-lift flap and, consequently, great ground effect on landing required the use of a powerful elevator.

CONTROL BOOSTERS

TABLE I
CONTROL FORCES FOR A LARGE AIRCRAFT

Item	Desirable Force	Maximum obtainable
Elevator force on wheel at full deflection ...	50 to 80 lb.	160 lb.
Rudder pedal—full deflection	150 lb.	500 lb.
Aileron—partial deflection—one hand ...	10 ft.lb.	35 ft.lb., right 30 ft.lb., left.

Critical Conditions

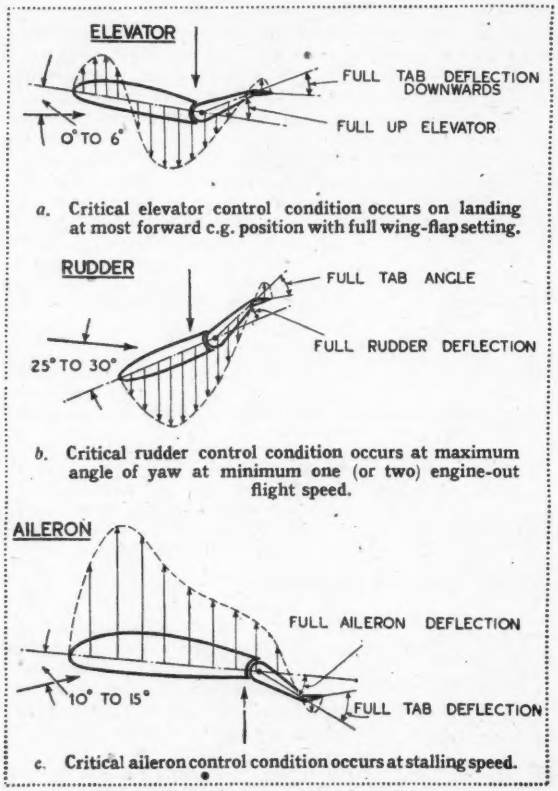
If it were not for these conditions of obtaining the ultimate in performance with one or two engines out on one side, of making minimum-speed landings, and of getting the greatest possible control at the stall, the problem of flying any aircraft with gross weights up to 250,000 lb. would be simple, and no power boosters would be required. The arguments presented in this paper for boost controls could all be nullified by accepting minimum control speeds 20 or 30 m.p.h. above those possible to obtain with the booster. However, the effect of this procedure on safety, required field length, aircraft economics under existing regulations, and overall manœuvrability is too apparent to require any discussion.

The final boost ratios used on the Constellation were much higher than any used on any other aircraft (generally around three or four to one). They are shown in Table II. All surfaces utilise a slight amount of servo action on the trim tab to make the ratios feasible. This does not increase drag, area, or weight.

To make clear several of the foregoing statements on the relative advantages of the mechanical booster over the aerodynamic booster (or balance), the most promising types of the latter will be considered. There are, of course, an infinite number of types of aerodynamic balance, used with varying degrees of success for different applications. To make a reasonable comparison, control surfaces having a constant area behind the hinge line are considered in each case to have the maximum amount of aerodyanmic balance feasible to apply without over-balancing at any

TABLE II
BOOST RATIOS ON THE CONSTELLATION

Item	Final ratio	Range of boost ratios tested
Elevator	9.33 to 1.0	9.33 to 23
Rudder	23.0 to 1.0	33 to 1 to 15 to 1
Aileron	26.0 to 1.0	26.0 to 1



a. Critical elevator control condition occurs on landing at most forward c.g. position with full wing-flap setting.

b. Critical rudder control condition occurs at maximum angle of yaw at minimum one (or two) engine-out flight speed.

c. Critical aileron control condition occurs at stalling speed.

Fig. 2. Critical design control conditions.

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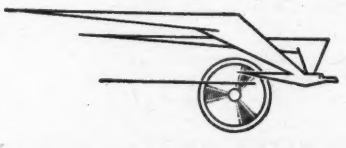
WINGS ARE THE WHEELS OF TO-MORROW



CONTROL BOOSTER

control-surface angle. This results in having a varying amount of aerodynamic balance ahead of the hinge line. The comparative data are based on wind-tunnel tests of models. Fig. 3 shows the four types of control surfaces considered; all surfaces are assumed to be equipped with combined servo-trim tabs.

Type I is the plain, unbalanced control surface of the type used on the Constellation.

Type II is the conventional, highly developed, elliptic-nose, overhanging-balance widely used on many aircraft of all sizes.

Type III is an effective internally balanced unit. The balance may be symmetrically located or, for elevators and ailerons, displaced to obtain more travel one way than the other.

Type IV consists of a bulge or modification to the elevator contour behind the hinge line.

Without attempting to present a mass of graphic data on the advantages of each type of surface, the comparison of the basic four is given in Table III.

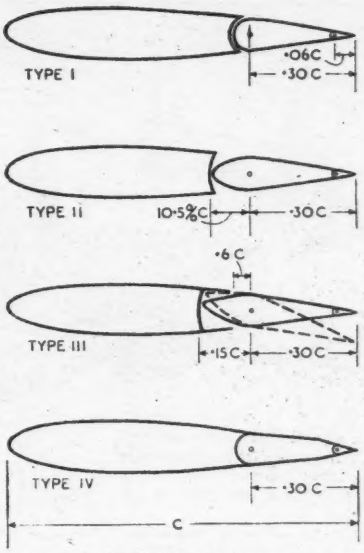


Fig. 3. Control surface balances compared in Table III. Data are based on Lockheed tests on 20 in. chord models.

In order to clarify the reasons for using such light control-booster ratios, some data will be presented as an example. A study was made of the more promising types of aerodynamic balance compared with the unbalanced type. Exhaustive wind-tunnel tests were undertaken to evaluate the advantages of all the basic means for reducing hinge moments. The four control surfaces shown in Fig. 3 were tested in comparative tests by a large model. To determine the interaction of all the tail components, a one-sixth scale model was constructed.

Flutter models having the proper deflection and frequencies were used and tested to destruction at high airspeeds.

With information from the research noted, Table III was prepared. Conditions for the comparison in the table are:

(1) A given control surface section, platform, and area (except as noted).

(2) Equal control surface chords behind the hinge line.

(3) Maximum amount of aerodynamic balance without over-balance at any angle of the control surface or angle of attack.

(4) Use of a combined servo-trim tab. (The use of aerodynamic over-balance plus an anti-servo tab is not considered.)

To simplify the comparison further, the use of the control surface for an elevator will be considered. In view of the fact that both the rudder and ailerons require a higher degree of hinge moment balance than the elevator (as noted by the boost ratios), this comparison is conservative in showing the advantages of the mechanical booster combined with Type I control surface. (Refer to Fig. 2 to see the design condition under which elevator control is critical.)

Type I control surface is similar to that used on the Constellation. It gives the highest lift, highest hinge moment, and lowest drag. Structurally, it is simple and strong.

Type II is the widely used overhanging-nose balance. It cannot develop as high a maximum lift because of leakage across the balance and an early stall due to the balance projecting. The surface gives a drag-increase of 12 per cent. or more over Type I. On a laminar-flow tail section the drag increase would be much more.

Type III has an internal balance with a cloth or rubber seal. This balance is sensitive to contour of the surface, gap and leakage. While the drag is good, the maximum control angle is severely limited, resulting in a low maximum lift. An asymmetrical balance-location can be used for elevators and ailerons but not rudders. The hinge moments obtainable are low, but the lack of effectiveness is serious. This can be improved by using a thicker tail section at a sacrifice in drag.

Type IV has a bulged trailing edge. This is effective on small, fast aircraft where stick forces in high-speed manœuvres are important, but it is not useful for the landing conditions.

For the case where maximum control is sacrificed and equal control surface areas are considered, Type I control with a booster on the Constellation saves 100 b.h.p. for the design cruising condition at 17,000ft. when compared to Type II. For equal overall control, where the area of Type II must be increased to get the same lift, the gain is approximately twice this amount. This saving of 200 b.h.p. results in an increase of 880 lb. for a trans-continental

TABLE III
COMPARISON OF CONTROL SURFACE TYPES.

Control surface type		I	II	III	IV
Maximum down-load comparison on landing with maximum elevator angle.	Surface area varied to get equal landing control.	100 per cent.	88 per cent.	78 per cent.	100 per cent.
Control surface angle for maximum lift.		40°	30° (balance precipitates stall)	20° (limited by clearance)	40°
Relative drag at cruising.		100 per cent.	112 per cent.	102 per cent.	102 per cent.
Hinge moment on landing (tab set for glide).		100 per cent.	47 per cent.	25 per cent.	96 per cent.
Hinge moment with area changed to get equal landing control.	Surface area kept constant.	100 per cent.	$\frac{100}{88} \times 47 = 53.5$ per cent.	$\frac{100}{78} \times 25 = 32.2$ per cent.	96 per cent.
Required boost ratio for 80 lb. control landing force on Constellation.		9.33	5.00	3.01	8.95
Effect of manufacturing tolerances and abuse.		Little effect.	Very sensitive to balance contour.	Extremely sensitive near gap for highly balanced surface.	Very sensitive to contour of control surface.
Compressibility effects at high speeds.		Most stable type.	Subject to over-balance in manœuvres.	Greatly subject to changes of aerofoil press. distribution.	Definitely unsatisfactory if highly balanced.
Approximate relative tail structural strength		100 per cent.	91 per cent.	86 per cent.	100 per cent.
Remarks on icing		Control surface practically unaffected.	Subject to ice formation on balance and therefore over-balance.	Subject to many adverse effects due to ice ahead of gap and water freezing in seal.	Probably unaffected by ice.

CONTROL BOOSTERS

flight. In terms of operating profit, this is a substantial gain and certainly worth working for. Note also that a boost unit is required even with the optimum forms of aerodynamic balance, so the installed weight of Type I surface, plus a high-ratio booster and its stand-by units, is no greater than that for Type II or III with the low-ratio units.

As aircraft get larger, the need for mechanical power to aid the pilot will increase. Compressibility effects will soon start to show up in high-altitude turbo-jet transports, as well as in military aircraft, so the vast field of possibilities for booster controls must be investigated as quickly as possible.

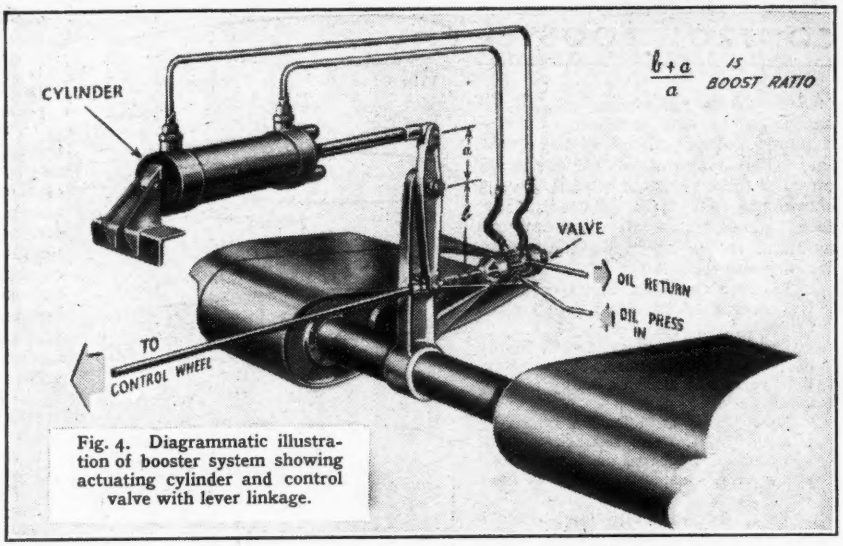


Fig. 4. Diagrammatic illustration of booster system showing actuating cylinder and control valve with lever linkage.

Careful analysis of the basic design requirements for booster systems was made, with the following conclusions:

(1) The cockpit control must always be connected directly to the control surface. A hydraulic connection was found to be extremely undesirable.

(2) The stick force should always be a given percentage of the total control-surface hinge moment at a given surface angle.

(3) The booster system must not "motor." With improper design, it is possible for any type of mechanical servo unit to act in reverse and drive the load. The basic theory has been worked out, and it is now possible closely to compute the booster frequency and actually make the booster act as a flutter-damper. This required the time of a highly competent mathematician for more than a year.

(4) It must be possible to fly the aircraft with no power.

(5) The rate of application of control-surface angle must be evaluated for each type of aircraft, and an adequate rate of booster response provided (about 40 deg./sec. on the Constellation). Furthermore, this rate must be provided under adverse and emergency conditions.

(6) Dual sources of power should be available automatically.

(7) Relief valves should be used to limit the maximum control-surface loads to their designed values.

(8) There must be no "dead spots," particularly through the neutral control point.

(9) The trim-tab effectiveness must not be lost due to boost friction.

(10) Rapid shut-off means should be provided.

(11) Until the basic elements are well proven in service, dual units or other auxiliary means must be provided for elevator and rudder control.

(12) The unit must be capable of operating at extremely low temperatures.

Complying with these conditions, the Constellation control system has proved to be a reliable and highly satisfactory method of obtaining the advantages previously outlined. The operating principles of the system are shown in Fig. 4. Any one engine, operating at idling speed or above, can supply power to operate all boosters in any conceivable manœuvre. Auxiliary elements are provided for the elevator and rudders. The elevator control, in addition, can be shifted in ratio, and with both hydraulic boosters off, one pilot can make a landing at about 100 m.p.h. using manual means only. Many such special precautions have, of course, been taken to ensure absolute safety in order to answer all criticisms on this unorthodox control arrangement.

To prove the design principles described, and to develop all phases of the hydraulic system, the hydraulic boosters, landing gear, flaps, pumps, complete plumbing arrangement, automatic pilot, brakes and cockpit were built-up in the laboratory to full scale. The exact space-relationship between all components was reproduced. Four Ford motors, controlled from the cockpit to simulate the aircraft engines, drove the hydraulic pumps. The air loads on the flaps and gear were simulated. Large springs were used to develop the actual air load existing on the elevators, rudders and ailerons. These loads were derived from wind-tunnel tests. Arrangements were made to reproduce the loads occurring at 80, 120, 200 and 350 m.p.h. to cover the full speed-range of the Constellation.

Freezing and Contamination Tests

This mock-up was used to study proper boost ratios, friction, effect of loss of engine power, interaction of all hydraulic components, and to do basic development work on the pumps, valves and all other components. The work went on for more than three years. To study the effect of low temperatures on the booster system, the whole tail assembly was enclosed and its temperature lowered to −70 deg. F. After freezing, the controls were operated and forces measured. Contamination tests involving the deliberate addition of dirt and water to the hydraulic fluid have also been run at normal and low temperatures. Cable-tension regulators to compensate for the change in fuselage length with internal pressure and temperature were developed to main uniform control feel under all operative conditions.

The laboratory tests did not answer all problems on the control boosters, primarily because the desirable control forces were not known until after the aircraft flew. A secondary factor was the effect of friction on trim, which was not simulated on the mock-up. On the whole, the laboratory tests were about 95 per cent. effective in covering flight conditions. One of the outstanding advantages of the control mock-up was that it provided the opportunity deliberately to abuse the various systems under safe conditions, thereby showing up potential weaknesses that probably would not have been uncovered otherwise. Both the engineers and flight test pilots soon provided a member of their groups to act as the official "wreckers" during tests. A secondary but important advantage of the mock-up was provided in that the pilot personnel could contribute their criticisms and comments during the design stages and also be shown all features of the design. This went far to get their enthusiastic support on the overall problem.

The basic information developed on this type of control has been used with a good deal of success to provide similar controls on several production Lockheed aircraft. It is felt that the principles have been well established and that the mechanical booster is the forthcoming type of control, not only for large aircraft but also for the small, fast high-speed type.

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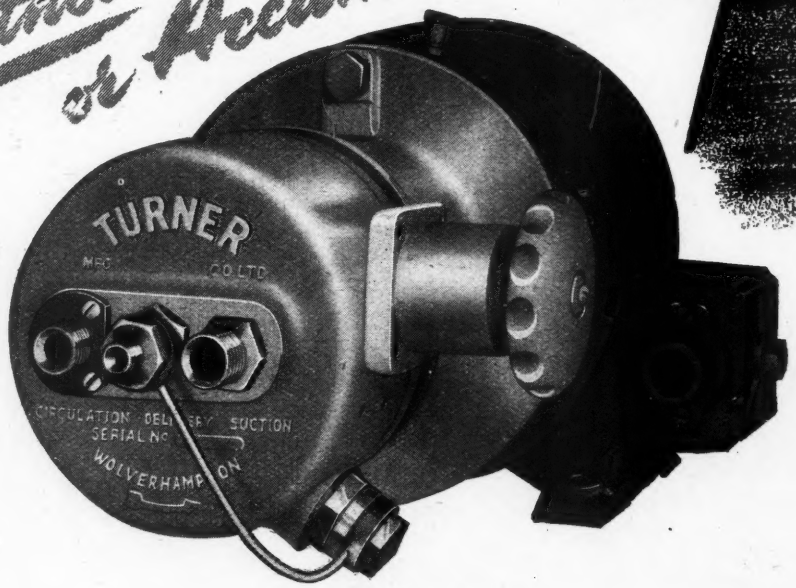

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IN PURSUIT OF SAFETY

Pre-war British Rotor Patents

IN *Flight*, January 24th, the writer observed a letter from S. H. Goodright suggesting retractable rotors for airliners. It might perhaps interest your correspondent and others, to learn that this idea, broadly, is now some ten years old—if not older.

The writer's patent No. 499,632 (applied for on April 14th, 1938) is the oldest and the pioneer *British* patent on this subject. This was followed by Patents of Addition Nos. 524,913 and 568,505. The broad idea was first patented by others in the United States several years before 1938. The writer's patents deal with the technicalities of aircraft stability as affected by the extension and operation of the rotor (or rotors), not with merely the broad idea of an extensible and retractable rotor for fixed wing aircraft, to which the American patents are limited.

The original patent was placed before all the leading aircraft manufacturers in Britain, United States, Germany, Italy, France, Holland and Japan, and also before the Air Ministries of all those countries. Strange to relate, it was the British who took the greatest interest in the idea. The consensus of opinion among British manufacturers was that the idea, broadly, was good, but they were not prepared to spend the large sum of money involved in the long-term research necessitated by this project, and there, for the present, the matter rests.

E. V. HAMMOND.

R.A.F. SLANG

Strips Were Torn Before 1928

I HAVE read with some amusement the explanations regarding the slang "tearing off a strip." One of your correspondents states it was derived from the Cardington balloon in 1939-40.

I myself, in company with many others, used this slang expression with great regularity at Halton in 1928, and we had it handed down by previous entries.

At one time, whenever anyone "shot a line" he was greeted with that rather rude noise commonly known as a "raspberry."

As we all know, this sound is very much like tearing a strip of cloth. So when anyone gave us the "bull," a wag would always invite us to "tear him one off"—and believe me we always did!

By the way, another slang expression used extensively is "gen," and I have heard many and varied stories as to its derivation.

It was first started as anything which was common knowledge or anything on orders for the "general information." The individuals who used to spread this information, sometimes with a few odd statements concerned with their own wishful thinking, were greeted with "Here comes the genman."

Now, however, it is applied to many things, mostly to people who are usually well informed in their particular sphere.

EX-HALTON BOY.

SPEED AND THRUST

Power Developed versus Work Done

I THINK "Indicator" rather misses one point in his explanation of the connection between thrust and horsepower in *Flight*, January 17th, and will tend to leave some confusion in the ordinary person's mind.

He compares a Merlin engine being "revved up" on the ground with a jet unit running under similar conditions, and states that the former is developing a large quantity of power, while the latter is developing none. Surely a layman would be justified in making the following comment on that statement:— "You say that the jet unit on the ground is giving no power (i.e., doing no work) because, although a large thrust is being created, the engine itself is not moving forward. Why then should we not say that the Merlin engine, too, is doing no work, since it is not moving forward either?"

The essential point is, of course, that we must be careful to recognise clearly the distinction between total power developed and power usefully employed, and to make sure that when we are comparing two engines under certain conditions we are considering the same type of power or work in each case.

Another point is that we must compare similar types of unit, i.e., things that can do the same job. It is of no more use to compare a jet engine with a Merlin engine by itself, than to compare a capstan lathe with a milling machine. A Merlin engine by itself cannot produce thrust (except for a small amount of exhaust thrust perhaps), but only torque, whereas a pure jet unit has no available torque, but gives a large thrust. The airscrew fitted to the Merlin engine is the means for converting torque into thrust, so that for comparison with the jet unit we must consider the Merlin-airscrew combination as a whole.

If we make the comparison on a total work basis, then we must say that both engines are doing work. The Merlin-airscrew combination is throwing backwards a large quantity of air with a medium velocity, while the jet unit is sucking in a smaller quantity of air, but is blowing it out at the back with a much greater velocity—if that isn't doing work, I don't know what is!

We can easily estimate the total power of "Indicator's" jet unit on this basis. For instance, suppose that the unit, in order to develop its 2,000lb. of static thrust, were pushing out 40lb. of air (exhaust gas) per second at a speed of 1,600 ft./sec. The horsepower ejected in the air is then equal to

$$\frac{Wv^2}{2 \times g \times 550} = \frac{40 \times (1{,}600)^2}{2 \times 32.2 \times 550} = 2{,}890 \text{ h.p.}$$

On the other hand, if we are to compare the units on a basis of useful power, i.e., power usefully employed in moving the engines (and their attached aircraft!) forward, then we must say that *neither* unit is developing any power, because neither is moving.

The apparent paradox of our having supposed originally that the Merlin was giving 2,000 b.h.p. is easily explained when it is remembered that that figure represents the total power available, and not necessarily the amount usefully employed. This latter depends on the propulsive (or Froude) efficiency of the airscrew, which is defined as the ratio of the power usefully employed to the power supplied in the airscrew shaft, and which is zero when the aircraft is at rest, just as the propulsive efficiency of the jet unit is zero when it is at rest.

THOMAS D. ROBERTS.

["Indicator" writes: "I agree with Mr. Roberts' further clarification, but I was really intending to be faintly ironic. Perhaps I should have explained that the "work" being done by the piston engine was that of turning the airscrew.]

AIR ACCIDENTS

Mistake to Disband R.O.C.

IN the past few weeks I have, in company with many others, been greatly perturbed by the seemingly ever-increasing number of air crashes that have occurred in this country. It is not my intention, however, to attempt to lay the blame for these mishaps at any particular door, nor to try to trace them back to any definite cause. Rather would I put forward a suggestion for the prevention of one of the most lamentable features of the majority of these crashes—the time lag between the actual crash and its subsequent discovery.

Surely the remedy for this lies in the immediate setting up of an organisation, comparable in size and scope with the Royal Observer Corps, for the plotting of all aircraft flying over the British Isles. During the war, besides giving warning of enemy aircraft, the Observer Corps kept track of all aircraft either seen or heard by their posts, and in the event of a crash were able to notify the appropriate authorities within a matter of minutes, thus saving the lives of many Allied airmen. But with a state of war no longer existing the Government saw fit to disband, or, to quote an official euphemism, "stand down" the R.O.C., with the result that, theoretically at least, any machine can fly over the whole length of this country and no one is the wiser.

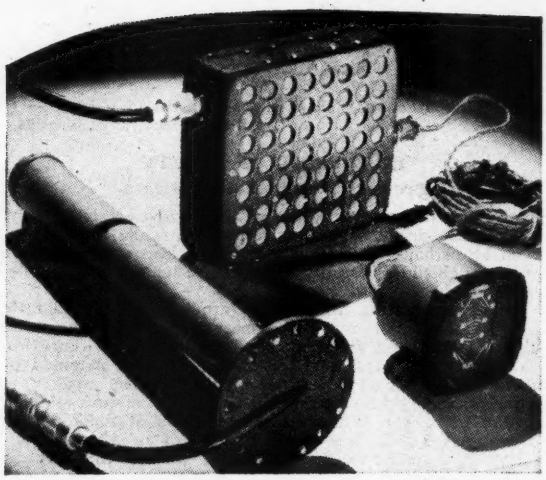
In addition to the inestimable benefit that speedy location and rescue would give to the occupants of crashed aircraft, in view of the enormous success of the R.O.C. in "homing" lost aircraft, and in preventing aircraft crashing into high ground, I venture to say that, with an organisation such as the Royal Observer Corps restarted, the number of air crashes would drop considerably.

G. A. B. SHORT.

THE INDUSTRY

Pacitor Fuel Gauge

Full Depth Reading with Electronically Operated Instrument: No Moving Parts

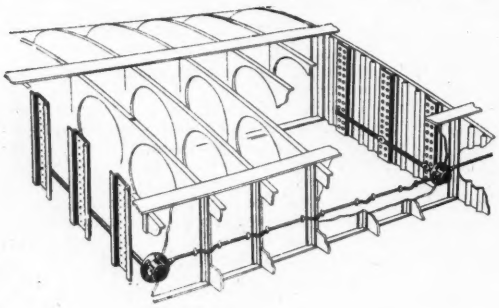


The three elements which make up the complete apparatus. On the left is a condenser unit of the flanged type suitable for any tank. The centre unit contains the electronic installation and the cockpit indicator is on the right.

IT is claimed by the makers that this new Simmonds fuel gauge will measure a mass of fuel, over all ranges of temperatures and basic specific gravities, to within 3 per cent. In addition, it is said that the reliability of the instrument remains constant regardless of extreme changes in flight attitude.

The principle employed is simple in the extreme. There are only three basic elements: a tank unit, which is a plain electrical condenser of parallel metal plates insulated from one another; a unit containing the electronic components; and the cockpit indicator. There are no moving parts in the complete circuit other than the actual pointer.

As fuel is consumed the proportion of fuel or air between the plates alters and affects the electrical capacity of the condenser tank units. This change of capacity is measured by the electronic circuit and passed on in the form of small direct currents to the cockpit indicator, which is a conventional D.C. type ratio-meter. Calibration of the indicator dials may be either in gallons or pounds of fuel. The latter is to be preferred because temperature affects volume whereas weight remains constant.



The stiffener type unit built-in as an integral part of the tank structure.

There is a variety of tank units including flanged, non-flanged and quick-assembly types. These are suitable for self-sealing, integral, and bladder tanks. A fourth type is designed to be a structural stiffener in addition to its normal function as an electrical condenser. The double-purpose application of this model saves a good deal of weight. In addition there is the advantage of ideal location for minimum of position error.

Empty and full adjustments are electrically independent of one another. By actual measurement, a plus or minus adjustment of as much as 10 per cent. on the full end of the indicator produces no readable effect on the empty end of the scale. Calibration adjustments are carried out on the indicator without disturbing the tanks.

Installation and other particulars may be had from Simmonds Aerocessories, Ltd., Great West Road, Brentford, Middlesex.

BIG CONTRACT

IT is said that de Havilland's contract to supply jet propelled Vampire fighters to the Swedish Air Force is in the region of £4,000,000.

RESTARTING

MR. WHITNEY STRAIGHT, who spent a fair proportion of the war years getting captured and escaping from the Germans, is starting up a flying training scheme in London.

AVIATION INSURANCE

MR. C. F. HUGHESDON, who did valuable test flying early in the war, including prototype trials on the Hamilcar, and who was awarded the A.F.C. in 1944, has been released from the R.A.F. and is now back as aviation director of Stewart Smith and Co., Ltd., Lloyd's brokers. Messrs. E. G. Outram and O. V. Holmes, also recently demobilised from the R.A.F., have joined the same company's aviation department.

CLEARING AGENTS

AIRPROP Passenger and Freight Services, Ltd., are now in full operation as airways clearing agents. The Board consists of Group Capt. W. A. Rollason, of Rollason Air Services, J. M. Wakeman and A. E. Lindsay.

Both Mr. Wakeman and Mr. Lindsay have been connected with airline work for over 25 years. The former will deal with freight traffic and the latter will look after the passenger side of the business. The address is Terminal House, Grosvenor Gardens, London, S.W.1.

FOR QUICKER JOURNEYS

A TAYLORCRAFT Auster has been acquired by Mr. C. D. Macartney-Filgate—a director of Tube Investments, Ltd.—to save time on his journeys to production conferences at the Group's more distant works and to make quick contacts with customers in Britain and on the Continent.

It is the first civilian aircraft of its type to be supplied since the war. Flt. Lt. D. G. Duval has been engaged as pilot.

MODERN PRODUCTION TECHNIQUE

THE necessary use of high-duty, heat-resisting sheet materials such as stainless steel, Inconel and nickel-chromium alloy for the fabrication of combustion chambers for aircraft gas turbines has set new welding problems for the manufacturers. Resistance welding has provided a satisfactory solution, and the subject is discussed by a Lucas engineer in the March issue of *Aircraft Production*, appearing next Monday, February 25th.

Other articles in the issue include a description of the "time-balanced" system used by Folland Aircraft, Ltd., in the sub-contract manufacture of Seafire Components; notes on the production of the Rolls-Royce Griffon 65; and a description of the methods by which junior draughtsmen are trained in the Fairey Company's draughtmen's school.

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A lively aircraft with no 'temperamental tricks'. A machine that is ready to take the air to-day, next week, next month or next year without constant adjustments and tuning. Fitted with a de Havilland Gipsy Queen II engine with constant speed propeller the Proctor has proved itself in the Services as unbeatable for reliability and ease of control. A comfortable four seater with a cruising speed of 140 miles per hour, generously equipped with full blind and night-flying instruments, landing lamps, navigation, cabin and instrument lights, and provision for the installation of radio (engine fully screened and airframe bonded).

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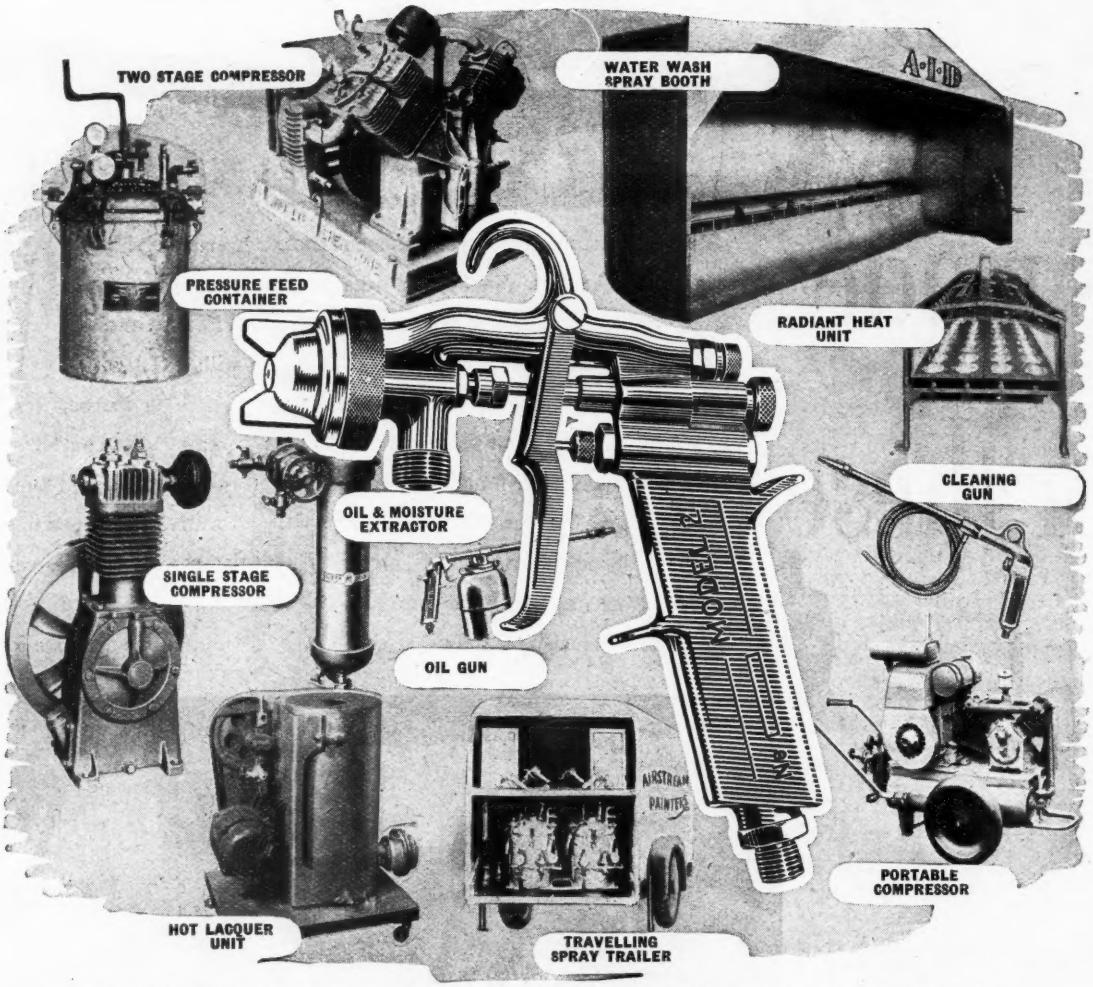
C.R.C.7

The GUN
and Everything Behind It



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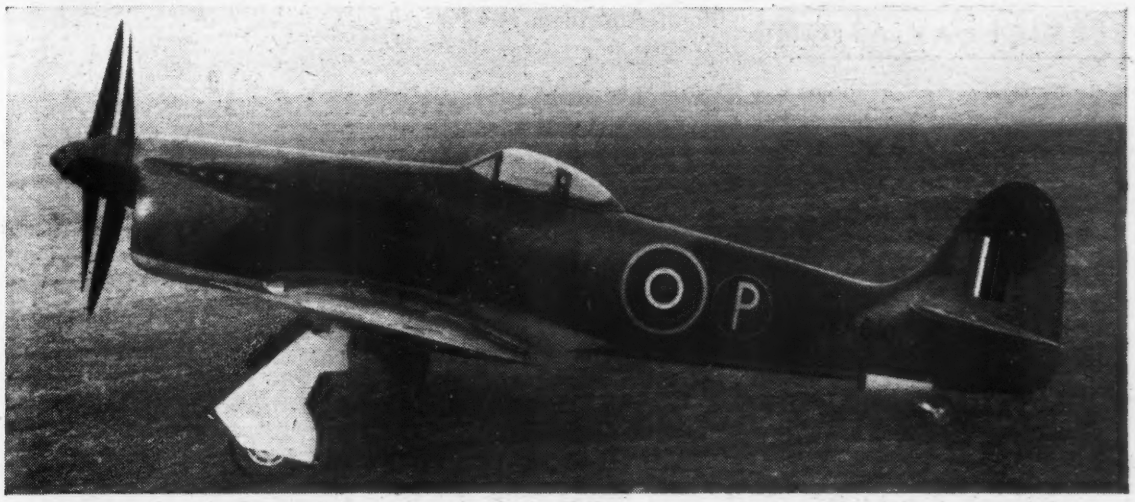


An experimental version of the Hawker Fury, fitted with a Griffon 61 engine driving contra-rotating airscrews. Production Furies and Sea Furies will be powered by Sabre and Centaurus engines.

SERVICE AVIATION

Royal Air Force and Naval Air Arm News and Announcements

Demobilisation

Releases for R.A.F and W.A.A.F.

THIS month's advance promulgation of age and service groups to be released from the Royal Air Force covers five months ahead instead of the usual three. It forecasts the release of the following groups:—

February.—Group 27.
March.—Group 28 and part of 29.
April.—Part of group 29 and groups 30 and 31.
May and June.—Groups 32, 33, 34 and 35.

The present forecast is, of course, subject to there being no unforeseen changes in the world situation. There is no doubt that one of the main anxieties of the men serving overseas is a sense of uncertainty as to when their turn for release is really coming, and it has been thought wise to let the men know where they are as far ahead as possible.

Demobilisation will not, of course, stop on June 30th next. The rate of release during the second half of this year will be largely governed by the enquiry affecting all three Services, to which the Prime Minister referred in his statement on January 29th last.

Appointments

AIR VICE-MARSHAL THOROLD, C.B., C.B.E., D.S.C., D.F.C., A.F.C., to be Senior Air Staff Officer, Flying Training Command.

Air Vice-Marshal C. A. BOUCHIER, C.B., O.B.E., D.F.C., to be Air Officer Commanding Air Group, British Commonwealth Occupation Forces in Japan.

Air Vice-Marshal J. D. L. HARDMAN, C.B., O.B.E., D.F.C., to be Air Officer in Charge of Administration, Air Command, South-East Asia.

Air Vice-Marshal Thorold was appointed Head of Air Section, No. 30 Mission, Moscow, in April, 1945. For the previous two years he was at H.Q., No. 92 Group, as Air Officer Commanding, and from June, 1940 to 1942 commanded R.A.F. Station, Takoradi, West Africa. In January, 1940, he was appointed to H.Q., B.A.F.F., as Officer in Charge of Maintenance. He received the C.B.E. in 1942 and the O.B. in 1945.

Air Vice-Marshal Bouchier was appointed A.O.C. No. 221 Group, Air Command, South-East Asia, in June, 1945, having previously been Air Officer Commanding No. 233 Group in the same Command. In 1944 he became S.A.S.O. No. 11 Group, having been previously on air staff duties at H.Q. Fighter Command.

In 1942 he was appointed Deputy-Director of Fighter Operations at the Air Ministry, and from December, 1939, to December, 1940, during the Battle of Britain, commanded R.A.F. Station, Hornchurch. He received the O.B.E. in 1936, the C.B.E. in 1941, and the C.B. in June, 1945.

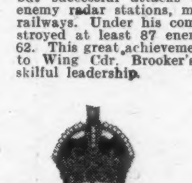
Air Vice-Marshal Hardman has been A.O.C. No. 232 Group, Air Command, South-East Asia, since February, 1945. He was previously Deputy Air Commander, R.A.F. Element, A.C.S.E.A. Before taking up the latter appointment he was Director of Military Co-operation at the Air Ministry, having been Deputy Director of Military Co-operation since September, 1941. In June, 1940, he was appointed to air staff (ops.) duty at H.Q. 22 Group, and at the outbreak of war was posted to the H.Q. Staff of the R.A.F. Component of the Field Force in France. He received the O.B.E. in 1940, and the C.B. in July, 1945.

Awards

THE KING has been graciously pleased to approve the following awards in recognition of gallantry and devotion to duty in the execution of air operations.

Bar to Distinguished Service Order

Act. Wing Cdr. R. E. P. BROOKER, D.S.O., D.F.C., R.A.F.*—From May to August, 1944, this officer led a wing of rocket-firing Typhoons, and during that time he completed many hazardous but successful attacks against heavily defended enemy radar stations, military headquarters, and railways. Under his command his wing have destroyed at least 87 enemy aircraft and damaged 62. This great achievement has been largely owing to Wing Cdr. Brooker's brilliant planning and skilful leadership.



Badge of No. 2 Maintenance Unit, R.A.F.—"Secundus sed nulli secundus" (Second, but second to none).

Badge of No. 6 Elementary Flying Training School, R.A.F. — "Experientia docet" (Experience teaches).

Distinguished Service Order

Act. Wing Cdr. R. E. BABY, D.F.C., R.A.F.O.*—Since the award of the D.F.C., this officer has taken part in numerous operational sorties. Under his brilliant leadership, the squadrons of his wing materially contributed to the success of the Sicilian campaign. Later in 1945, Wing Cdr. Baby completed many bombing and low-level attacks in Spitfire aircraft, displaying throughout brilliance and courage as a pilot and leader. In February, 1945, he led his squadron in a highly successful attack on a heavily defended bridge at Grisolera and, a month later, he located and attacked a concentration of railway transport to such good effect that four locomotives were destroyed and over 70 goods trucks damaged. In addition, he has been tireless in organising and leading missions in close support of the Eighth Army. An outstanding wing leader, this officer gained the absolute confidence of all the pilots under his command.

Distinguished Flying Cross

Flt. Lt. H. E. MCNEIL, R.C.A.F., No. 436 (R.C.A.F.) Sqn.
Flt. Lt. C. F. WILLIAMS, R.C.A.F., No. 159 Sqn.
F/O. W. DREW, R.C.A.F., No. 159 Sqn.
F/O. W. J. HOLLAND, R.C.A.F., No. 436 (R.C.A.F.) Sqn.
F/O. G. W. LINEHAM, R.C.A.F., No. 435 (R.C.A.F.) Sqn.
F/O. W. B. LINTON.
F/O. O. B. PHILP, R.C.A.F., No. 436 (R.C.A.F.) Sqn.
F/O. B. S. WYGLE, R.C.A.F., No. 436 (R.C.A.F.) Sqn.
W/O. T. PATTERSON, R.C.A.F., No. 357 Sqn.

Distinguished Flying Medal

Flt. Sgt. L. R. DOBSON, R.A.F.V.R., No. 117 Sqn.
Flt. Sgt. A. S. OSMASTON, R.A.F.V.R., No. 357 Sqn.

* Since deceased.

Roll of Honour

Casualty Communiqué No. 563.

THE Air Ministry regrets to announce the following casualties on various dates. The next of kin have been informed. Casualties "in action" are due to flying operations against the enemy; "on active service" includes ground casualties due to enemy action, non-operational flying casualties, fatal accidents and natural deaths.

Of the names in this list 240 are second entries giving later information of casualties published in earlier lists.

Royal Air Force

KILLED IN ACTION.—L.A/C. A. Appleyard; F/O. E. F. Clemens; Sgt. E. A. Cox; F/O. E. Hadley; Act. Flt. Lt. R. C. Hawkins, D.F.M.; Sgt. C. W.

SERVICE AVIATION

Knight; Flt. Lt. J. A. Round, D.F.C.; F/O. M. Watson, D.F.M.

MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—W/O. W. H. Holliss.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—W/O. H. S. Cruttenden; Sgt. L. Garratt; F/O. S. T. Lee; F/O. R. F. Marsh; P/O. W. G. Musgrave; Flt. Sgt. C. A. Peatey; Sgt. W. J. D. Smith; Sgt. J. Swainston; L.A/C. A. Swallow; Sgt. J. D. Wade; F/O. D. W. O. Wood.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. T. A. Arlow; Sgt. A. Ashby; Sgt. J. H. Balman; Sgt. N. Barker; Sgt. R. E. Barnicoat; W/O. T. P. Barry; P/O. G. Baxter; Flt. Lt. R. D. Bell; Sgt. D. Betterton; Sgt. C. Booth; Sgt. A. G. Bowen; P/O. G. W. Bradshaw; Sgt. N. Bradshaw; Sgt. S. Brook; Flt. Sgt. T. Bryan; Act. F/O. W. J. P. Buchanan; Sgt. P. W. Buckley; Sgt. W. R. Bush; Sgt. H. B. Carter; Flt. Sgt. J. Casebrook; Flt. Lt. H. C. A. Chapman; P/O. C. Charalambous; Sgt. T. C. Clitheroe; Sgt. C. N. Collingwood; Flt. Sgt. S. J. Compton; Act. F/O. G. F. Coombs; Sgt. C. J. Crane; Sgt. F. D. Crawford; Sgt. L. E. Daglass; Sgt. W. J. B. Doughty; Act. Sqn. Ldr. R. K. Eggins, D.F.C.; P/O. J. T. Evans; Sgt. F. Fearn; P/O. E. T. Fisher; Act. Wing Cdr. G. F. Georgeson, D.S.O., D.F.C.; Flt. Lt. J. Gilmour; Sgt. E. C. W. Goode; F/O. J. P. Graham; Sgt. E. Greenwood; Flt. Sgt. F. Guest; Sgt. S. A. Gumbrell; Sgt. G. Hancock; Sgt. G. R. Harvey; P/O. R. T. W. Harwood; F/O. W. E. Hearn; Flt. Sgt. K. Hibbert; Act. F/O. E. Hill; Flt. Sgt. G. E. Holland; Flt. Sgt. S. J. Honour; Flt. Sgt. I. E. Hurley; Sgt. B. L. Jaeger; Flt. Sgt. J. B. Johnson; Sgt. E. N. Jolley; F/O. D. S. Jones; Sgt. L. B. Kelsey; Flt. Sgt. P. M. Kitto; Sgt. H. N. Lloyd; Sgt. T. Lock; Sgt. G. H. Lucas; Sgt. H. J. Mallen; Sgt. W. H. Maltman; Act. Flt. Lt. F. A. Marden, D.F.C.; Sgt. J. Marshall; F/O. S. M. Masters; Sgt. E. Meering; F/O. W. H. J. Mills; Sgt. A. Milne; Sgt. T. Moore; Sgt. C. A. Morton; F/O. J. B. Moss; Sgt. M. Muir; Sgt. C. B. Osborne; Sgt. R. Palmer; F/O. J. W. Patterson, D.F.C.; Sgt. A. R. Pattillo; Sgt. A. Payton; Sgt. D. K. J. Phillips; Sgt. D. H. Phillips; Sgt. G. W. Picker; Sgt. S. A. Picton; Sgt. W. C. Porter; Sgt. J. Purves; Sgt. N. A. Readman; Sgt. G. T. Robinson; Sgt. D. A. T. Roffey; Flt. Sgt. J. Rowe; Act. F/O. A. J. Sargent; W/O. K. Scholes; Sgt. J. R. Scott; Sgt. T. Setchfield; Sgt. E. Shackleton; W/O. R. A. Simpson; Sgt. S. Sinclair; Sgt. F. C. A. Stokes; P/O. R. J. Stone; Sgt. G. T. Sutherland; Sgt. R. E. Thomas; Sgt. J. Tweedie; Sgt. J. R. Ward; Act. Flt. Lt. M. Ward, D.F.C.; W/O. J. C. Watson; Act. Flt. Lt. H. W. D. Watts, D.F.C.; Sgt. J. Webster; Sgt. R. S. Westrope; Flt. Sgt. J. Wheeler; Sgt. M. Whiteley; Sgt. N. V. Wilding; Sgt. F. J. Wilson; Sgt. H. C. J. Winslade; Flt. Sgt. W. F. Worsley.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—Flt. Sgt. J. Johnson; MISSING.—Flt. Sgt. R. W. Cuming; Flt. Lt. T. Woodhouse.

KILLED ON ACTIVE SERVICE.—L.A/C. J. C. Cameron; Flt. Sgt. R. E. G. Chase; W/O. G. S. Crispin; F/O. H. W. Daniels; Flt. Sgt. D. Davenport; Flt. Sgt. T. Davies; L.A/C. C. P. Heaps; L.A/C. L. S. Holmes; Cpl. R. W. Hubbard;; Flt. Sgt. J. E. Johnstone; L.A/C. J. V. H. Kitchener; L.A/C. E. J. Long; Sgt. D. Lumley; Flt. Sgt. C. Meikle; Flt. Sgt. G. Milner; Cpl. T. J. O'Riordan; W/O. J. C. Portway; A/C.1 F. C. M. Sage; L.A/C. L. J. Schuler; P/O. D. Simpson; Flt. Lt. E. A. J. Smith; Sgt. E. S. Stephen; A/C.1 W. C. Stewart; F/O. W. Sykes; Flt. Sgt. J. P. Taylor; A/C.2 R. B. Wilson; Flt. Sgt. E. G. Wood.

MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—P/O. P. M. Cook; P/O. F. E. W. Stephenson.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. B. G. Barker; Sgt. A. J. Birrell; Sgt. C. P. Davidson; Sgt. W. N. Jenkins; P/O. P. O. Metcalfe; Sgt. L. M. Langley; Sgt. F. Laws; P/O. E. C. Mitchell; P/O. A. Rockliffe; Sgt. L. P. Willetts; Flt. Lt. A. J. E. Young.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Flt. Sgt. J. Marshall; W/O. C. Stacey.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—W/O. D. J. Jenkins.

DIED ON ACTIVE SERVICE.—Sgt. T. Alcock; A/C.1 L. A. Aspinall; Act. Flt. Lt. P. G. N. Booth; W/O. E. Callander, D.F.M.; A/C.1 C. Coffey; L.A/C. W. G. Coles; A/C.2 T. V. Cook; Cpl. G. Fisher; Act. Flt. Lt. L. F. Hilborne; L.A/C. V. S. G. Houghton; A/C.1 P. Humphreys; Sgt. D. Jamieson; L.A/C. F. Johnson; L.A/C. J. H. Letby; Act. Sqn. Ldr. A. M. MacGill, D.C.M.; Flt. Sgt. A. L. Midlane; L.A/C. W. E. Morgan; Cpl. V. Munro; F/O. A. W. North; L.A/C. S. Phillips; L.A/C. D. Pike; Flt. Sgt. L. W. Preston; Sgt. R. J. Reddecliff; L.A/C. A. R. Rook; A/C.2 J. Shaw; L.A/C. A. J. Sherfield; Flt. Lt. L. Shire; L.A/C. L. A. Smith; L.A/C. A. R. Swynford; L.A/C. A. Threlfall; L.A/C. M. R. Thurlow; L.A/C. R. J. Vincent; L.A/C. T. Walker; A.C.1 A. J. Williams; Act. W/O. W. Wills.

Women's Auxiliary Air Force

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—L.A/CW. M. Campbell.

Royal Australian Air Force

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—F/O. J. P. M. Brady; Flt. Sgt. E. J. Kenealy; P/O. J. F. Loughnan; F/O. C. G. Middleton; W/O. L. G. Robinson; P/O. E. Thompson.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Flt. Sgt. N. Brand; F/O. A. F. Cunningham; P/O. H. W. E. Donald; W/O. I. H. Gray; Flt. Sgt. I. Hunter; Flt. Sgt. J. E. J. Kelly; Flt. Sgt. P. H. M. Levey; Flt. Sgt. A. B. Llewellyn; F/O. D. W. MacLean; Flt. Sgt. G. H. Newman; W/O. J. Philip; F/O. B. T. Roberts; Flt. Sgt. K. H. Rowley; P/O. G. A. Skinner.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—F/O. N. J. M. Manfred.

KILLED ON ACTIVE SERVICE.—P/O. J. P. Hynes; F/O. A. H. Pivott.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—P/O. H. H. Chapman.

DIED ON ACTIVE SERVICE.—F/O. J. W. Thorpe.

Royal Canadian Air Force

KILLED IN ACTION.—F/O. G. D. Bowes; Flt. Lt. W. M. Bowlen; P/O. L. J. M. Eisler; Flt. Lt. H. I. Malmas.

MISSING BELIEVED DIED WHILST PRISONER OF WAR, NOW PRESUMED KILLED IN ACTION.—P/O. E. K. Wilson.

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KILLED ON ACTIVE SERVICE.—F/O. W. L. Knight; Sgt. M. M. Smith; Sgt. A. R. Thomson.

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DIED ON ACTIVE SERVICE.—L.A/C. L. H. Bauer; Sqn. Ldr. T. J. Decourcy; L.A/C. J. Hutton; F/O. J. P. F. Palleck; L.A/C. H. R. Wallbridge.

Royal New Zealand Air Force

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Flt. Sgt. R. C. Morgan; Flt. Sgt. R. W. Newman.

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Air Chief Marshal Sir Arthur Sheridan Barratt

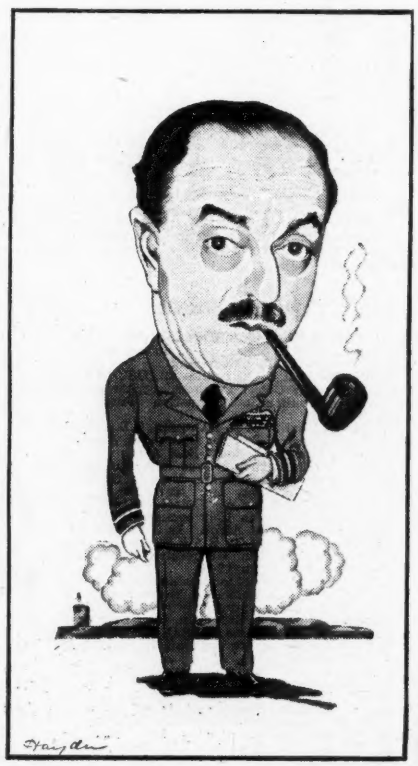
(Caricature portrait by Hayden)

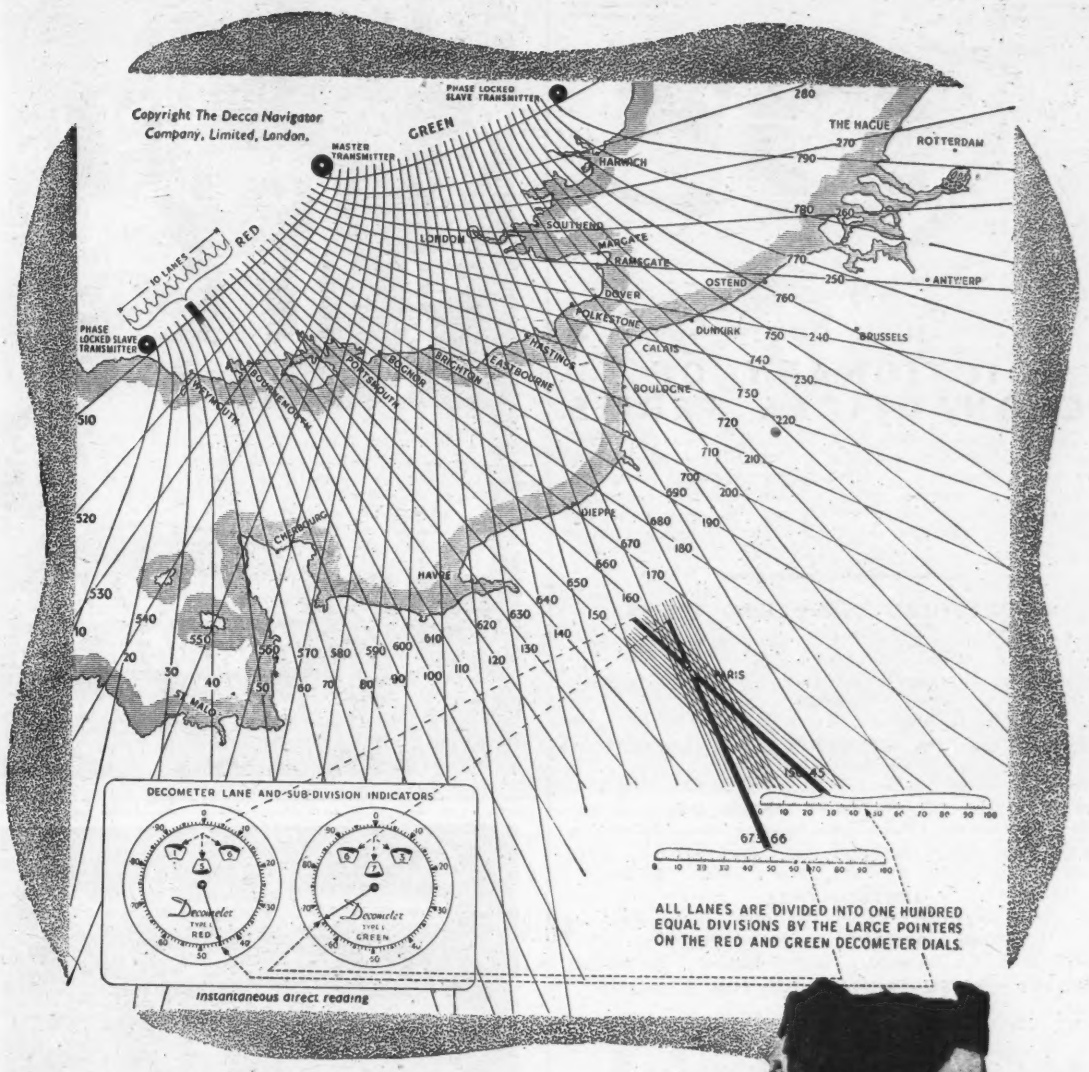
AIR CHIEF MARSHAL SIR ARTHUR SHERIDAN BARRATT, K.C.B., C.M.G., M.C., was educated at Clifton, and joined the Royal Artillery from Woolwich in 1910. In 1914 he was seconded to the Royal Flying Corps, and joined No. 3 Squadron in France. There he won the Military Cross and was also made a Companion of the Order of St. Michael and St. George. He was also granted some Belgian decorations.

In 1924 he attended the Army Staff College at Camberley, and then was posted to command the School of Army Co-operation at Old Sarum. In fact, army co-operation work was the side of the R.A.F. which most attracted him, probably as a result of his early experience as a gunner.

However, he was in 1921 posted to the R.A.F. Cadet College at Cranwell. In 1927 he went to Shanghai for air staff duties with the local Defence Force. Then he was an instructor at the R.A.F. Staff College at Andover. In 1931 he went to India to command No. 1 Indian Group. On promotion to Air Commodore next year, he became senior air staff officer at R.A.F. headquarters in India. In 1934 he returned home to fill a post at the Air Ministry. In 1936 he was promoted Air Vice-Marshal and was given the command of the Andover Staff College.

When in 1940 the Advanced Air Striking Force and the Air Component of the Expeditionary Force were combined to form the Command of the R.A.F. in France, Barratt was made A.O.C.-in-C. of the new Command. After Dunkerque the Air Ministry formed the Army Co-operation Command, and again Barratt was appointed A.O.C.-in-C. This Command, however, never undertook major operations, and in 1943, it was merged into 2nd Tactical Air Force when the latter was formed. Upon this merger becoming effective, Sir Arthur Barratt, who had commanded Army Co-operation Command throughout its wartime existence, took over Technical Training Command, where he remained as Commander-in-Chief until the latter part of last year, when he was appointed Inspector-General of the Royal Air Force. He was promoted to the rank of Air Chief Marshal on January 1 this year.





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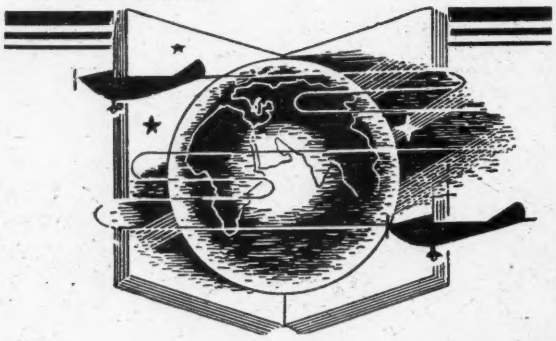

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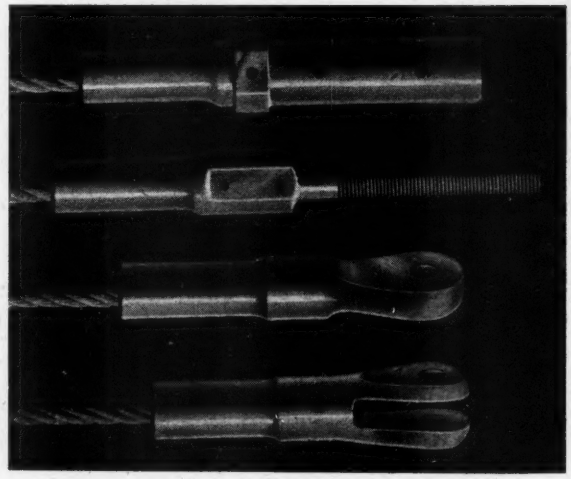

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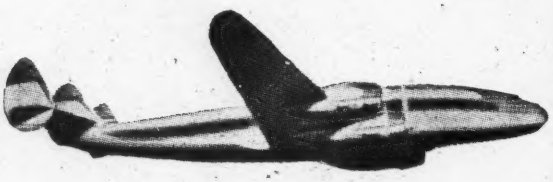

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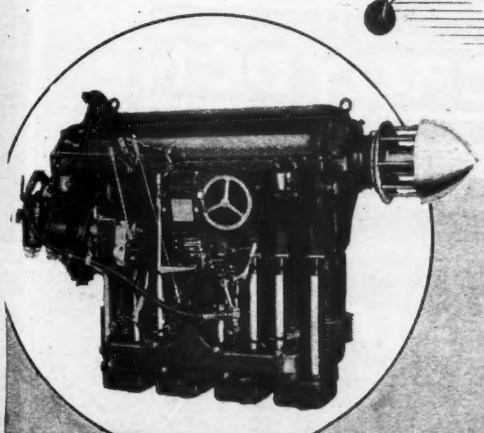

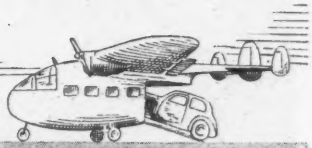

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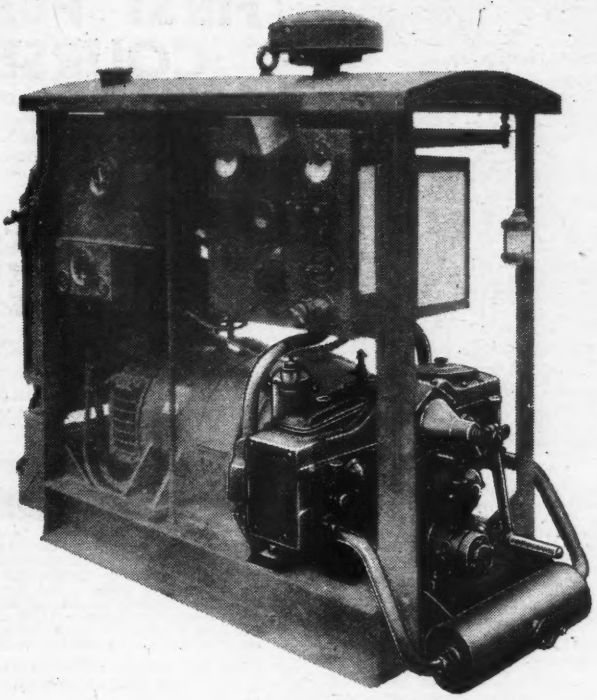

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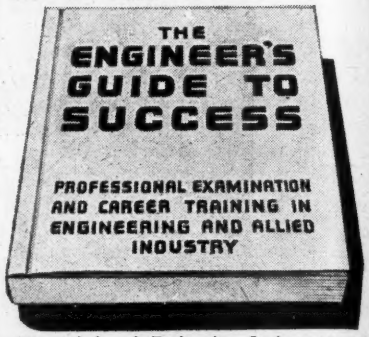

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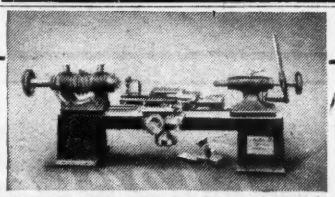

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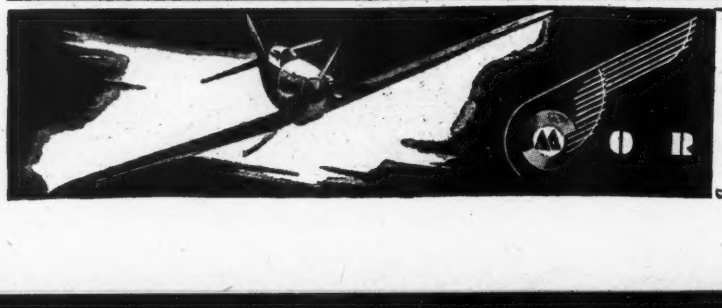

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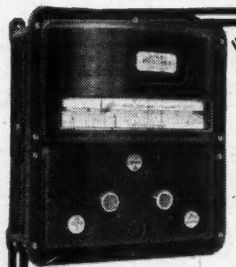

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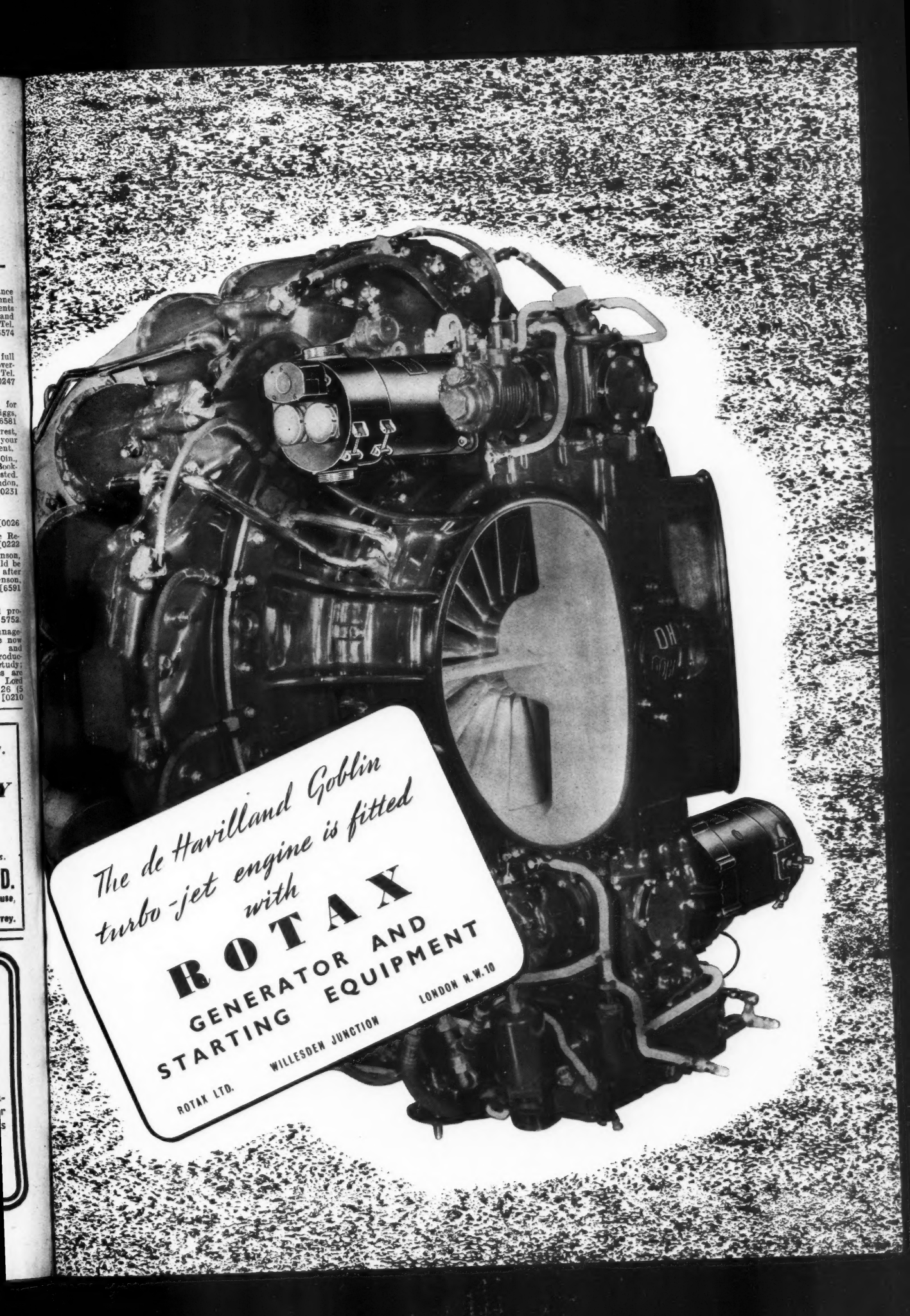
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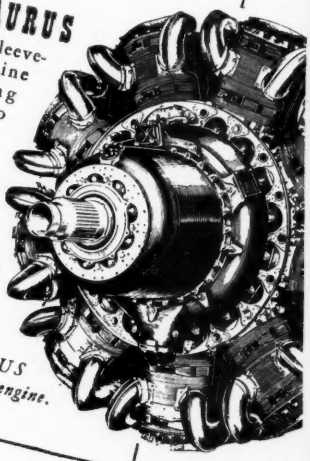

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